
Nova Scotia
OIL AND GAS REPORT

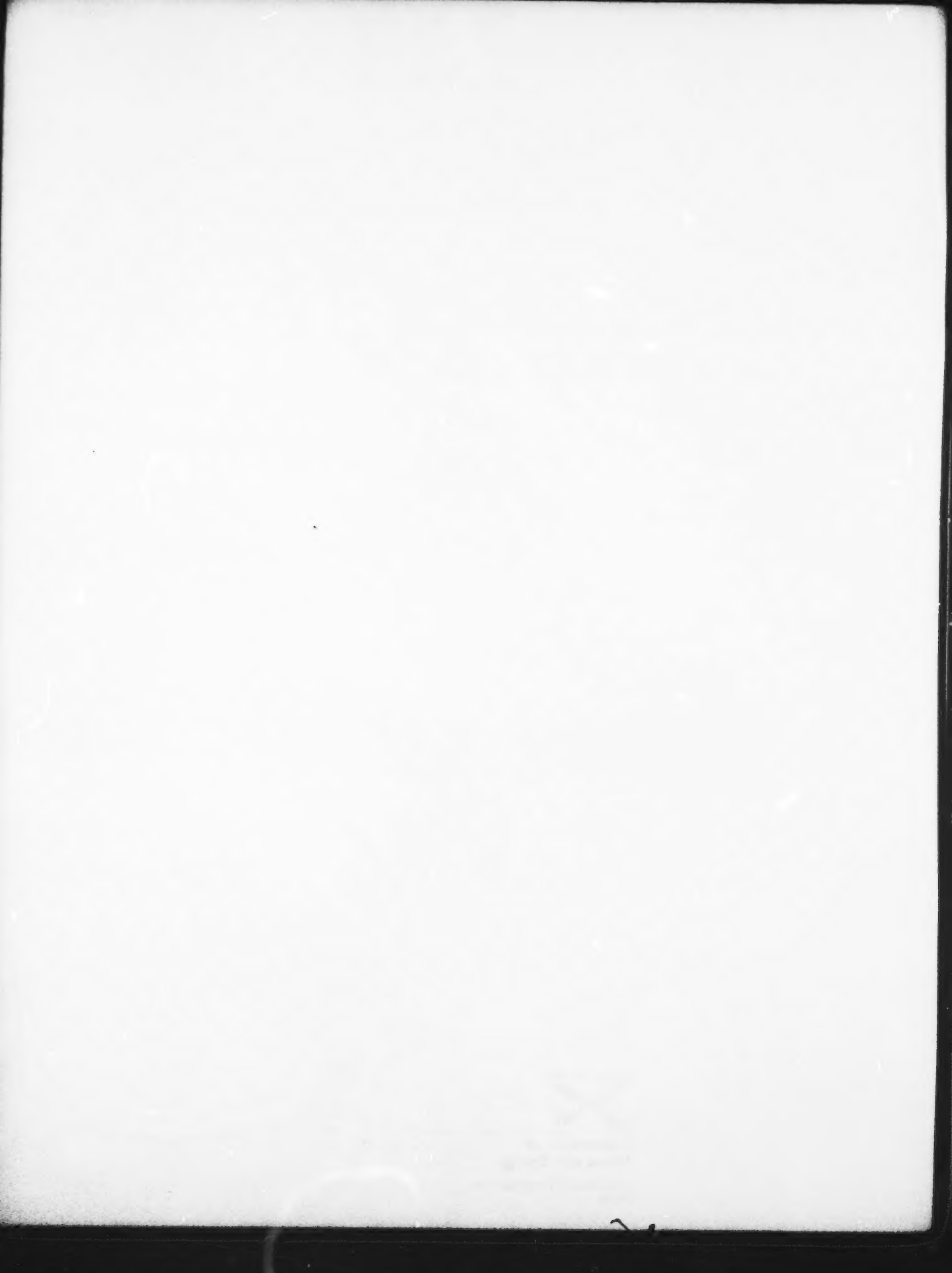
1984

Nova Scotia



**Department of
Mines and Energy**

Honourable Joel R. Malheson, Q.C.
Minister



MINISTER'S MESSAGE

It is my pleasure to present this report on oil and gas exploration and development in Nova Scotia. The information contained in these pages will contribute to a better understanding of events both offshore and onshore that are leading to eventual production of Nova Scotia's own petroleum resources.

Exploration for oil and gas is surely one of the most exciting developments in the province and it is certainly the one with the greatest potential impact on the future prosperity and financial health of Nova Scotia.

The current phase of exploration activity in Nova Scotia's offshore region began in earnest in 1982, although the impetus was the discovery of natural gas at the Venture D-23 well in late 1979. Exploration accelerated in 1983 and continues at a high level today. Five major operators, including several of the world's largest oil companies, are actively searching with their partners for oil and gas in Nova Scotia's offshore. Agreements negotiated by mid-1984 committed exploration companies to drill 46 wells by 1988, of which 14 have been drilled and eight more started. Exploration companies will spend more than one billion dollars in completing these commitments.

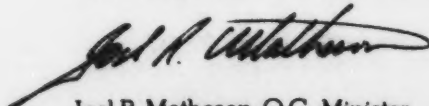
Their efforts have not been without result. Four natural gas discoveries, at Alma, Glenelg, Uniacke, and Arcadia, were made within the past year. Of the past 16 wildcat oil and gas wells drilled on the Scotian Shelf, seven have discovered significant quantities of natural gas, an excellent success rate for the petroleum industry.

Delineation drilling offshore and extensive engineering work onshore continues in preparation for development of Venture natural gas, the first offshore discovery from which commercial production is anticipated. Mobil Oil Canada Limited and its partners estimate the cost of the Venture Project, including offshore facilities, pipeline to shore, and onshore processing facilities, at more than 2.5 billion dollars, which would make it the largest single project ever undertaken in Nova Scotia.

Once processed onshore, the sales gas will be transported to markets in Canada and the United States through a transmission pipeline across Nova Scotia and New Brunswick to the United States border. Natural gas consumers in Nova Scotia will be served by a provincial gas distribution company fed by laterals from the main transmission line. Construction of this transmission and distribution system will mean the investment of more than one billion dollars over and above the cost of the Venture Project itself.

The activity generated by oil and gas exploration expands the opportunities available to both business and individuals in Nova Scotia. The Department of Mines and Energy is working with the petroleum industry and the federal government to ensure orderly and safe exploration and development of our offshore petroleum resources for the maximum benefit of Nova Scotia.

It is my sincere hope the exploration for oil and gas offshore Nova Scotia continues to meet with the success of the past few years and I look forward to many more rewarding discoveries and events in the years ahead.



Joel R. Matheson, Q.C., Minister



CONTENTS

PART I

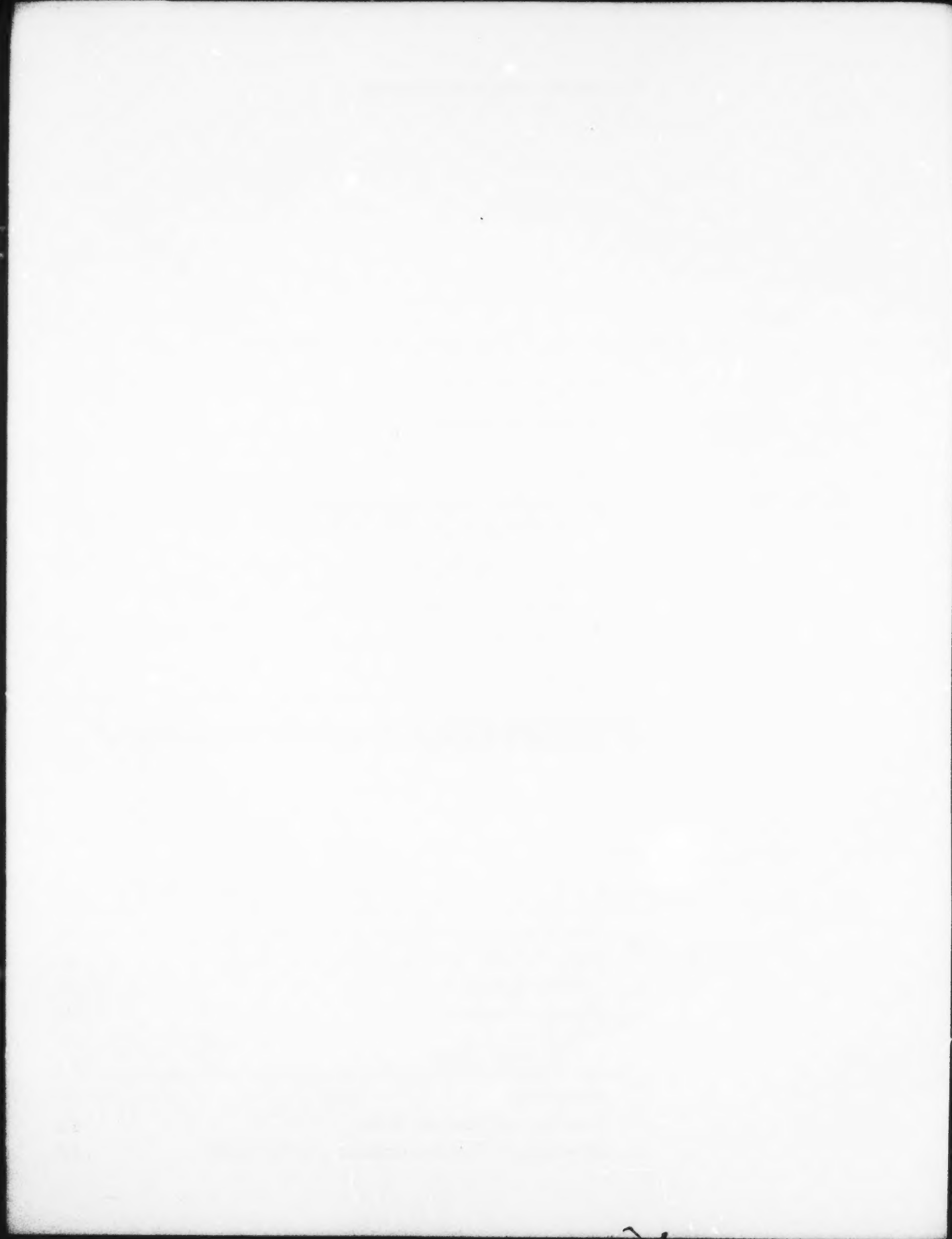
OIL AND GAS EXPLORATION AND DEVELOPMENT

	OFFSHORE	8
1	Geological Setting	8
2	Exploration Agreements	11
3	Exploration Activity	14
4	Oil and Gas Discoveries	17
5	Legislation and Administration	19
	THE VENTURE PROJECT	22
1	Offshore and Onshore Facilities	22
2	Activity and Update	26
	ONSHORE	28
1	Geological Setting	28
2	Exploration Activity	31

PART II

PETROLEUM INFORMATION

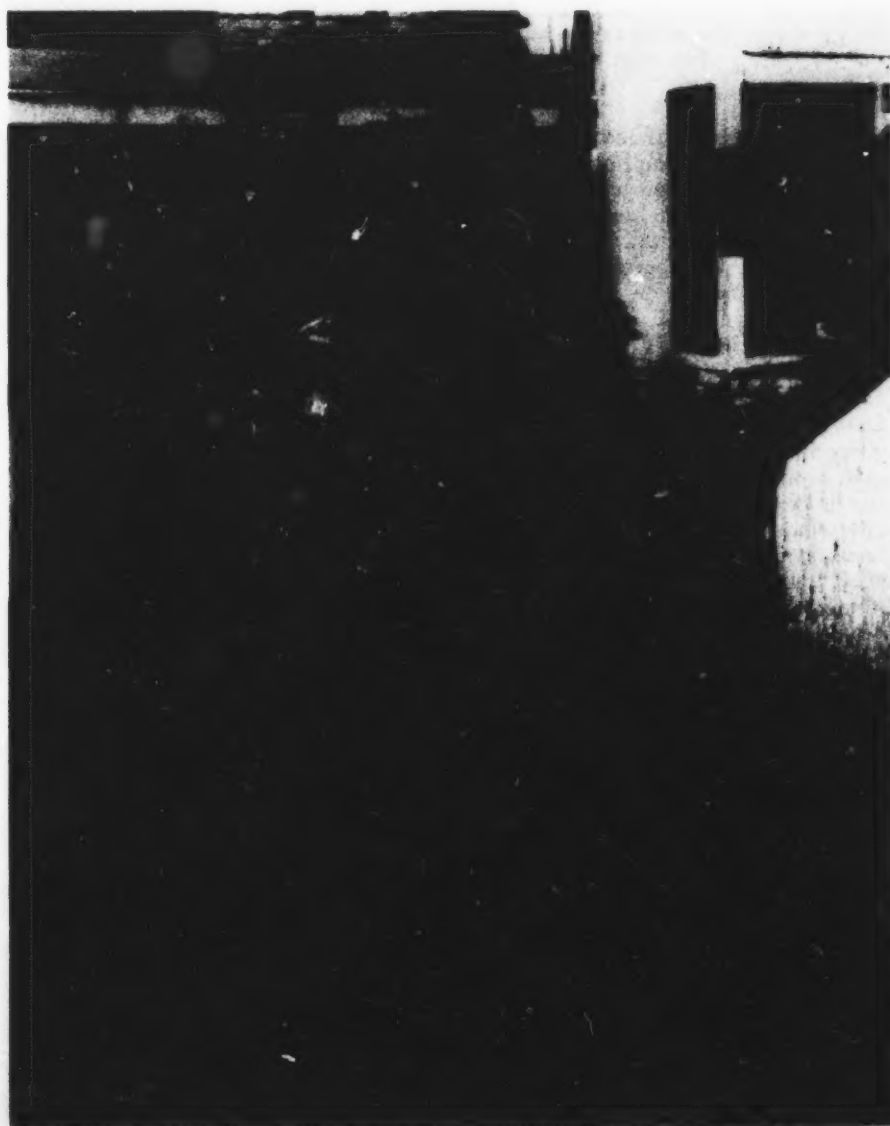
	EXPLORING FOR OIL AND GAS	34
1	The Geophysical Survey	34
2	Offshore Drilling Units	36
3	Drilling Operations	37
4	Oil and Gas Plays	39
	APPENDICES	41
1	Definitions	41
2	Directory of Offshore Wells	42
3	Directory of Onshore Drilling — 1946-1984	47



P A R T I

OIL & GAS EXPLORATION
& DEVELOPMENT

*Roughnecks on the
Zapata Scotian adding
pipe during drilling of
West Venture N-91.*



OFFSHORE

1 GEOLOGICAL SETTING

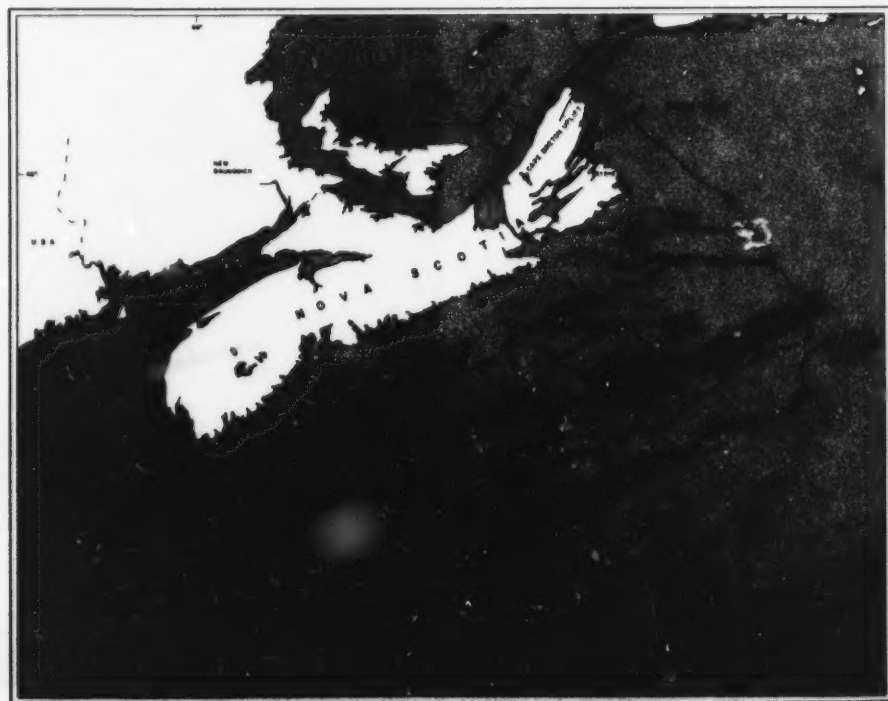
Nova Scotia's offshore region covers an area of approximately 100 million acres (40 million ha) and includes both the Scotian Shelf and the Scotian Slope which form part of the continental margin of eastern Canada. The margin is composed of three distinct parts; the continental shelf, which gently tilts away from the coast for approximately 150 miles in water depths of up to 1,300 feet (400 m); the continental slope, a much shorter zone where water depths increase fairly rapidly to 8,200 feet (2 500 m); and the continental rise, a narrow band of sediment around the continental margin.

The areas of greatest interest for oil and gas exploration are the zones of the Scotian Shelf and Slope which are underlain by thick accumulations of sedimentary rocks.

The Scotian Shelf is one of Canada's largest sedimentary basins. Covering about 40 million acres (16 million ha), it stretches for about 435 miles (700 km) from Georges Basin in the west to the Laurentian Channel in the east, varying in width from 76 to 142 miles (122 to 228 km). About 36 million acres (14.6 million ha) of this area is currently licensed for oil and gas exploration. Sediments capable of producing hydrocarbons are found throughout the Scotian Shelf. The greatest thickness of sediments were deposited in the Sable Island Sub-basin (Figure 1) and it is here the majority of oil and gas discoveries on the Shelf are located.

The undersea topography of the shelf divides into three distinct areas. The Inner Shelf extends seaward 15 miles (24 km) from the coast line at water depths of 330 to 395 feet (100 to 120 m). The topography is rough and similar to the adjacent land mass. The Central Zone extends seaward from an inner trough for distances of

1 Physiographic features at Lower Cretaceous time.



between six miles (10 km) at the western end and 70 miles (110 km) at the eastern end. An irregular series of basins, including Roseway, La Have and Emerald, and banks, including Roseway, Sambro, Middle Canso and Misaine, are located in this zone. The Outer Shelf is 30 to 45 miles (48 to 72 km) wide, parallels the edge of the shelf and contains, five broad, flat-topped banks, Browns, Le Have, Emerald, Banquereau and Sable Island, the largest of the five.

Extending 160 miles (257 km) east-west and 50 miles (80 km) north-south, Sable Island Bank contains the island itself, a 20 mile (32 km) long, narrow arc of sand. Altogether 42 wells have been drilled in the Sable Island Sub-basin (out of a total of 92 wells on the Scotian Shelf and Slope), including nine wells drilled on the island itself.

Formations that occurred during the Jurassic and Cretaceous periods (210 to 140 million years ago) are central to creating the hydrocarbon potential of the Scotian Shelf and the Sable Island area in particular. Sediments were laid down in this area in stages beginning with a thick layer of salt deposited in early Jurassic time. This layer was deposited in a rift basin formed as the North American continent separated from the North African land mass (Figure 2). Subsequently buried under (now) overlying rocks, the salt flowed upward to form domes and pillows that now underlie many of the hydrocarbons bearing structures in the Sable Island area.

Carbonate banks, including the Baccaro carbonate front, formed a thick belt of limestone during the second stage of deposition in Jurassic time. These banks along the end of the Scotian Shelf and through the Sable Island area are composed of potential hydrocarbon reservoir rocks. Throughout the remaining Cretaceous time, a wide coarse clastic sandstone known as the Missisauga Formation was deposited over the shelf margin and the Baccaro carbonate front. Seaward of this front, the coarse sands gradually become interbedded with more shale and finally pass to shale. As the carbonate mass was completely buried by the sandstone and shale, a series of subsea deltas was created extending across the Scotian Shelf (deltas and their associated thick sandstones have been a major factor in accumulations of oil and gas around the world). Finally, the sea drowned out the deltas in late Cretaceous time, covering them with shale.

The creation of hydrocarbon reservoirs on the Scotian Shelf coincides with the formation of these deltas, the presence of sandstone reservoirs, structures caused by the movement of salt in combination with growth faults and organic material swept in by river systems that formed the deltas.

The Sable Island Sub-basin and Abenaki Sub-basin were centres of maximum deposition of sediment. The major hydrocarbon finds to date are primarily confined to the centre of maximum deposition that passes through these areas. Shale and sandstone deposited as alternate layers provide source and reservoir rocks, thick organic rich sediments buried deep enough to generate hydrocarbons and relief caused by deep salt layers and/or basement block configuration contribute the necessary ingredients to the formation of oil and gas fields.

Hydrocarbons have been found in reservoirs ranging from the Late Cretaceous to Upper Jurassic time. The most consistent and successful oil and gas discoveries have been related to the down-to-basin structural faults that extend through the Sable Island Sub-basin. The fault system parallels the Baccaro carbonate front

O F F S H O R E

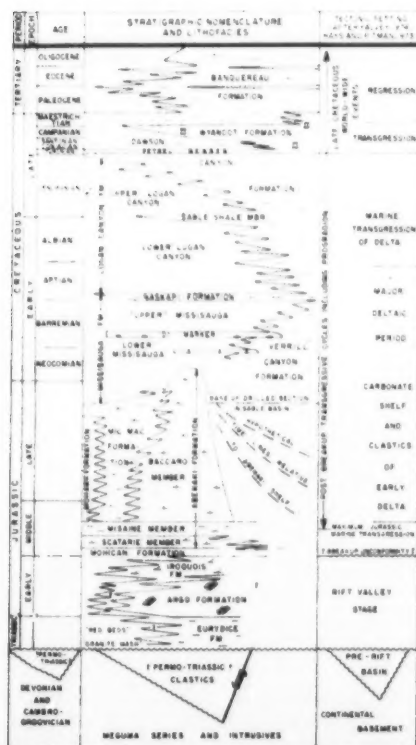
seaward. It is in the Mississauga Formation, consisting of interbedded sandstones and shales of Late Jurassic and Early Cretaceous age, that the gas producing zones of sandstones have been discovered in the Venture field. These sands are by and large overpressured. The D-23 Venture discovery well, for instance, tested gas in six zones of Lower Cretaceous sandstones between 13,300 and 16,200 feet (4 054 and 4 938 m).

Hydrocarbons have also been found associated with the salt dome structures that underlie much of the sediment in the Sable Island area. These structures have, however, proved to be severely faulted and the hydrocarbon distribution has been complex as a result.

North of the Scotian Shelf and east of Cape Breton, the offshore sediments are once again older. Drilling offshore Sydney Basin identified sediments that are an extension of the onshore and, thus, are from Pennsylvanian through Mississippian in age.

The Magdalen Islands Basin, south and west through the Northumberland Strait and including northern Nova Scotia, has the potential to contain a thick Carboniferous sequence with many related evaporitic structures. This was evidenced by the Hudson Bay F-25 well that bottomed in Lower Mississippian at a depth of 9,875 feet (3 010 m).

2 Stratigraphic diagram of lithologic units.



2 EXPLORATION AGREEMENTS

The exploration agreement is a relatively new vehicle for managing offshore oil and gas exploration activity. These agreements accomplish three basic tasks: they define the area a company can explore for oil and gas; they specify the amount of work the company must perform during the agreement; and they set out the rate at which land must be returned, or "relinquished", to the Crown.

Prior to signing of the Canada-Nova Scotia Agreement on Offshore Resource Management and Revenue Sharing (March 2, 1982), oil and gas rights to acreage offshore Nova Scotia were issued both provincially and federally. The offshore agreement provided for the offshore region to be jointly administered. Under the agreement, oil companies formerly holding provincial licenses or federal leases negotiated exploration agreements with the Canada-Nova Scotia Offshore Oil and Gas Board. Since March 2, 1982, 33 separate exploration agreements have been negotiated covering 41 million acres offshore Nova Scotia (Figure 3). Of the 46 wells to be drilled by 1988 under these 33 agreements, 14 have been completed and eight more started (Figure 4).

3 Exploration
Agreements under
Canada-Nova
Scotia Agreement.

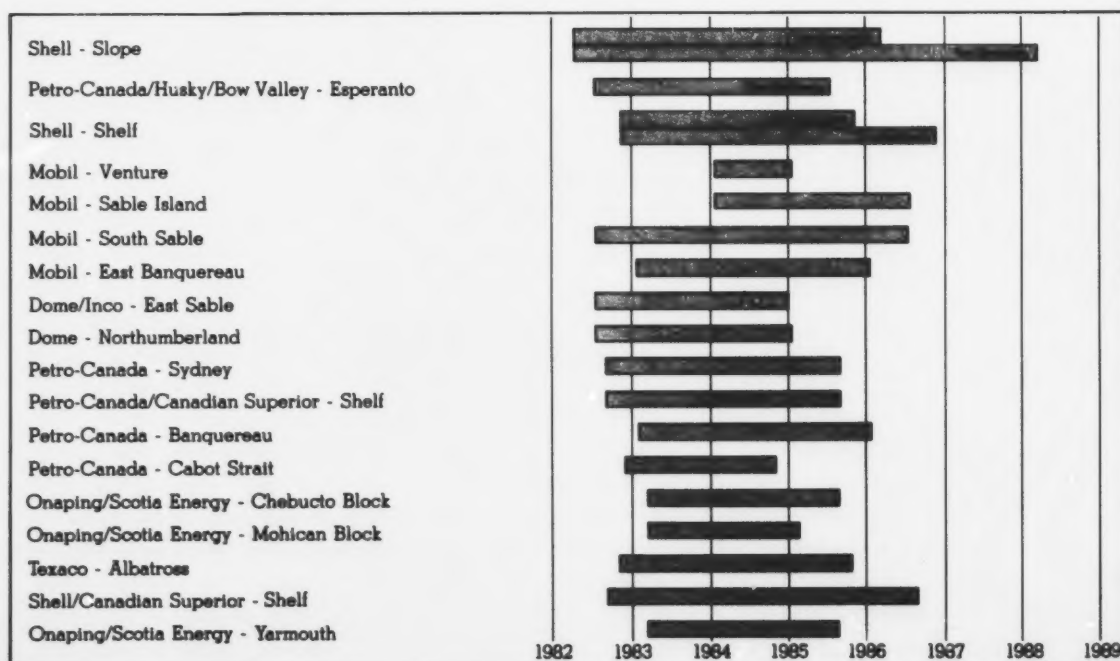
AGREEMENT DESCRIPTION	AGREEMENT NUMBERS	AREA (ACRES)	NUMBER OF E.A.s	NUMBER OF WELLS	\$MM (MILLIONS)
Shell — Slope	107-112	9,595,651	6	6	263
Petro-Canada/Husky Bow Valley — Esperanto	114-117	4,199,954	4	8	500
Shell — Shelf	118-124	4,849,945	7	9	551
Mobil — Sable Island (Terminated 1984-01-14)		1,145,750	1	4	197
(Commenced 1984-01-15)	254,255		2	5	284
Mobil — South Sable and East Banquereau	146,147	2,430,309	2	2	110
Dome/Inco — East Sable	150	593,040	1	2	113
Dome — Northumberland	149	1,455,419	1	1	14
Petro-Canada — Sydney	257				
Petro-Canada/Canadian Superior — Shelf	258	2,275,760	4	4	200
Petro-Canada — Banquereau	259				
Petro-Canada — Cabot Strait	256				
Onaping/Scotia Energy — Mohican and Chebucto	260,261	1,575,639	2	2	110
Texaco — Albatross	263	281,097	1	1	38
Shell/Canadian Superior — Shelf	264	229,800	1	1	36
Onaping/Scotia Energy — Yarmouth	262	751,869	1	1	34
SUB-TOTAL		29,384,233	33	46	2,450
Area under Moratorium (International Boundary Disputes)		11,706,843			
TOTAL		41,091,076			

August, 1984

A typical exploration agreement encompasses a block area averaging 600,000 acres (242 820 ha), calls for work to be done over a three-year term, and returns 50 per cent of the land to the Crown mid-way through the term. The work commitment normally involves the shooting of a seismic program, the extent of which depends on the existing seismic on the exploration agreement block, and the drilling of one or more wells. Shell and partners, for instance, have negotiated 13 exploration agreements covering some 14 million acres (5.7 million ha) and requiring 15 wells to be drilled.

All exploration agreements have the provision of relinquishment, or simply, the surrendering of lands. This makes land available to new companies, allows for increased control of exploration activity and maintains the pace of exploration. The relinquishment generally provides for a 50 per cent reduction in a company's holdings before the end of the three-year term of the agreement. This relinquishment may be accomplished in two rounds of 25 per cent each. At the time of relinquishment, the operator is allowed to protect "Significant Discovery" and "Work Program Prospect" areas from the relinquishment process. A discovery is significant if the first well on a geological feature shows the existence of hydrocarbons which, when flow tested, appear to have potential for production. Work program prospects are areas which will be drilled prior to the expiration of the agreement and for that reason are treated as exclusions from the relinquishment. If a well is being drilled on the block at the time of relinquishment, the relinquishment may be carried forward until 45 days following the completion of the well.

4 Duration of
Exploration
Agreements under
Canada-Nova
Scotia Agreement.



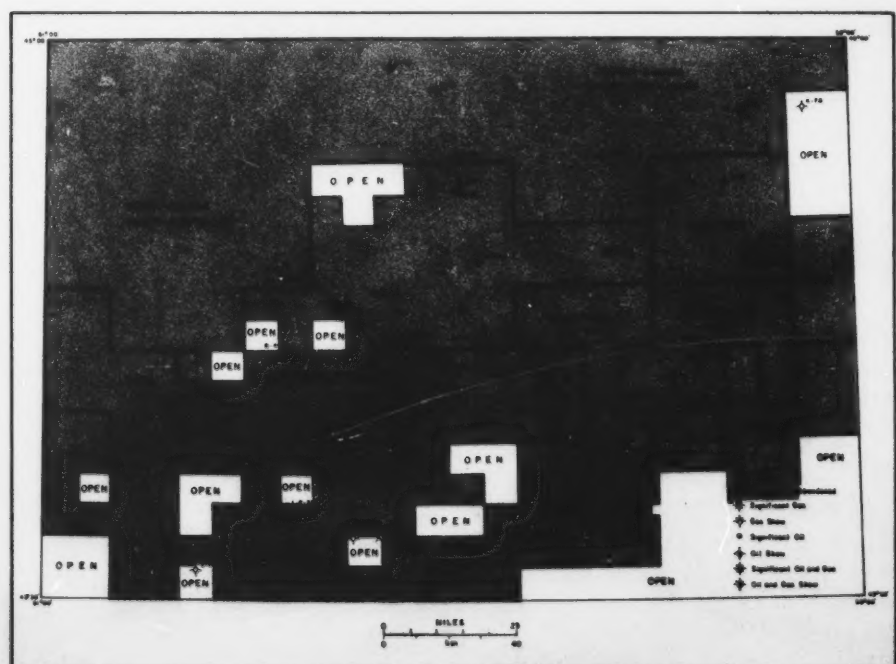
August, 1984.

Before the actual commencement of any work program under an exploration agreement, a Benefits Plan must be approved outlining the industrial, employment and social benefits expected for Nova Scotia and Canada from the proposed activity. The operator of the exploration agreement must obtain a *Drilling Program Approval* to give the company authority to operate a particular drilling rig in a specific region for a pre-designated period of time. An *Authority to Drill a Well* must then be obtained for each well approved under the drilling program.

At the end of the term of an exploration agreement, the company can either renegotiate another term, as in the case of the two exploration agreements renegotiated by Mobil on its Sable Island block, or surrender the lands to the Crown (Figure 5). This allows land to be made available to other companies. Since mid-1982, six million acres (2.4 million ha) have been relinquished to the Crown.

Companies negotiating the exploration agreements are not required to carry out all the required work themselves. In fact, many companies, including Husky, Bow Valley and Home, have become involved in the offshore through farm-in agreements; that is, an agreement between two companies in which the original company agrees to share, or "farm-out" its holdings and the new company "farms-in", or agrees to do certain exploration work in return for a share in the land or profits from any production.

5 Large Scale Map of Sable Island area.



August, 1984.

3 EXPLORATION ACTIVITY

The current phase of exploration activity offshore Nova Scotia, which began in 1982, continued at a strong rate through 1983 and 1984. The remaining commitments under existing exploration agreements and the rate of discoveries offshore point to continued high levels of activity in future years. Oil and gas exploration remains concentrated in the Sable Island area (Figure 6). Ten wells were started in 1983 and, in the first six months of 1984, another eight wells were spudded (Figure 7). Not since the early 1970s has drilling activity reached a comparable level. Nine drilling rigs were operating offshore Nova Scotia at one time during the past year, resulting in more than four times the number active in 1981 and more than double the number of rigs at the peak of activity in the 1970s.

Five major operators, in conjunction with numerous partners, are actively searching for oil and gas offshore (see centrefold). Of these, Shell, Mobil and Petro-Canada, hold dominant positions as interest holders and control the majority of offshore lands licensed under exploration agreements. Husky/Bow Valley and Home Oil have become operators as well, but through farm-in agreements with major license holders.

SHELL

Shell has once again become a significant operator offshore (it drilled 34 wells between 1969 and 1974). Three very encouraging gas discoveries have recently been made by Shell, Alma F-67, in mid-1984; Uniacke G-72, in early 1984; and Glenelg J-48, in late 1983.

6 1983-84 Offshore well locations.



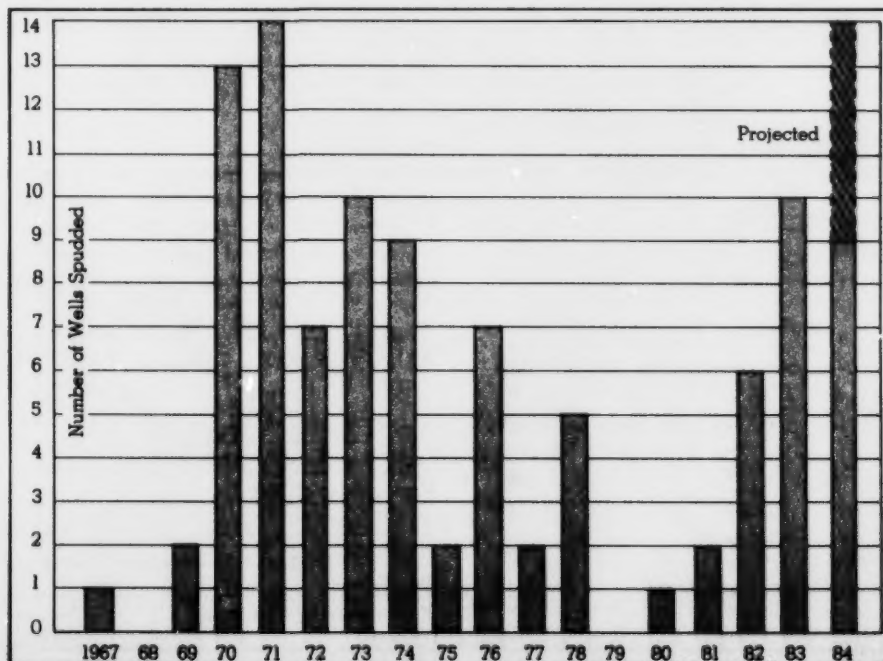
Glenelg J-48 and Uniacke G-72 were the second and third wells respectively of a 15-well exploration program to be completed by 1988 on Shell shelf and slope lands. The first well drilled was Shubenacadie H-100, completed in February 1983. A fourth well, Bonnet P-23, was drilled for Shell by Petro-Canada as operator under one of Shell's exploration agreements. Shell and partners started the fifth well, Alma F-67, in December 1983, and the sixth well, South Desbarres O-59, is currently drilling. Future plans include additional wells to appraise the gas discovery wells Alma F-67 and Glenelg J-48. Two semi-submersible drilling rigs, the *SDS Vinland* and the *Sedco 709* remained busy for Shell during the past year.

During testing of the Uniacke G-72 well on February 22, 1984, a blowout occurred forcing immediate evacuation of the *SDS Vinland*. The blowout was the first in the history of oil and gas exploration in Nova Scotia. Blowouts happen when a formation fluid (in this case, natural gas and condensate) under high pressure enters the well bore and cannot be controlled by pressure control equipment fitted to the well. The blowout was successfully brought under control and the well killed 10 days later on March 3, 1984. The *SDS Vinland* was able to complete the well without returning to port for repairs.

MOBIL OIL

Mobil and partners continue to actively explore on their Sable Island block. They satisfied the work commitment under their first exploration agreement, which expired on January 14, 1984, by drilling four wells. One of these wells, Arcadia J-16, encountered significant gas. Two Venture wells (Venture B-52 and Venture H-22) were drilled to delineate the southeastern and southwestern lobes of the

7 Drilling activity
offshore Nova
Scotia 1967-1984.



O F F S H O R E

Venture structure. The fourth well, Bluenose 2G-47, was drilled to offset and deepen a well drilled in 1971. Two new exploration agreements negotiated on the Sable Island block call for five wells to be drilled over two and one-half years. Analysis of new seismic data gathered in the summer of 1983 off the western end of the Venture Field has identified two structural anomalies with the potential for gas bearing sediments in the same interval as the Venture gas discovery. Two wells (West Venture N-91, started in April 1984, and West Venture C-62, started in May 1984) are being drilled to evaluate these two structures. Completion of these wells, which will serve as two commitment wells under the new exploration agreements, is scheduled for late 1984/early 1985. If additional reserves are proved by these two wells, the structures will be incorporated into the development plan for Venture.

PETRO-CANADA

Petro-Canada and partners completed four wells in 1983-84; St. Paul P-91 (December 1983), S.W. Banquereau F-34 (August 1983), Bonnet P-23 (April 1984) and Dover A-43 (July 1984). The Bonnet well is situated on a Shell shelf exploration agreement. The exploration agreements on the four Esperanto Blocks call for eight wells to be drilled over the next three years. The *Bow Drill 1* semi-submersible drilling rig remained active for Petro-Canada.

HUSKY/BOW VALLEY

Husky/Bow Valley finished Glooscap C-63, their first well on the Scotian Shelf in January 1984. The *Rowan Gorilla 1* jackup rig constructed in Vicksburg, Mississippi, arrived on the offshore scene at the end of 1983 and drilled Husky/Bow Valley's second well, South Griffin J-13. The *Bow Drill 3*, constructed in Saint John, New Brunswick, commenced drilling Husky/Bow Valley's third well, Evangeline H-98, in late March 1984. This well was temporarily suspended in mid-June when the *Bow Drill 3* moved to Newfoundland waters. It is expected to be scheduled for completion in late 1984 by the *Bow Drill 2*, drilling, as of August 1, the Chebucto K-90 well, Husky/Bow Valley's fourth well.

HOME OIL

Home Oil and partners began drilling their first offshore well (Louisbourg J-47) in November 1983, using the *Glomar Labrador 1* jackup rig, built in Dunkirk, France. It arrived on the Scotian Shelf in late 1983 to begin work for Home Oil. Plans are being made to drill a second well to satisfy the 2-well commitment on the East Sable Block following completion by the *Glomar Labrador 1* of Louisbourg J-47.

Currently (mid-1984) seven rigs are operating in the Nova Scotia offshore region and a high level of activity is expected to continue for the remainder of 1984 (Figure 8).

8 Offshore statistical
summary 1981-84.

		1981	1982	1983	1984 ¹
Exploration Agreements Concluded		10	20	3	0
Miles of Seismic Shot		11,662	19,016	23,153	3,181
Wells Spudded		2	6	10	9
Wells Completed		1	5	11	6
Rigs Active ²		2	6	7	8
Dollars spent by Operators (millions)	Seismic Drilling	17.4 65.0	37.3 220.0	48.9 547.7	N/A N/A

¹ To mid-July

² Average number of rigs working during the year

August, 1984.

4 OIL AND GAS DISCOVERIES

Ninety-two wells have been drilled offshore Nova Scotia since the first was completed on Sable Island by Mobil in 1967. Twelve significant natural gas discoveries and three significant oil bearing structures have been recorded (Figure 9). Four natural gas discoveries made by wildcat wells in late 1983 and early 1984 are considered significant (Figure 10). All four, three by Shell and partners and one by Mobil and partners, were made on previously unexplored structures.

ALMA

Alma F-67 was drilled for Shell and partners by the *Sedco 709* to a total depth of 16,581 feet (5 054 m). The Alma structure is located 43 miles (69 km) southwest of the western tip of Sable Island. The well, completed in July 1984, recorded a combined flow of 61.2 million cubic feet per day (1.7 million m³/d) of gas and 709 barrels per day (113 m³/d) of condensate primarily from three zones below the 9,000-foot level.

GLENELG

The Glenelg J-48 well recorded the highest flow rates of the four. Drilled to a total depth of 16,890 feet (5 148 m) by the *Sedco 709*, the Glenelg J-48 is located 28 miles (45 km) southwest of the western tip of Sable Island. It was completed in November 1983. Shell and partners reported a combined flow rate for six zones tested over a gross interval of 10,045 to 13,000 feet (3 061 to 3 962 m) of 92.4 million cubic feet per day (2.6 million m³/d) of gas and 640 barrels per day (102 m³/d) of condensate. Appraisal drilling in the form of one or more additional wells is planned for the Glenelg structure to evaluate the commercial viability of this discovery.

9 Summary of tests — significant hydrocarbon discoveries.

OIL (Significant Shows)	Wells Drilled Into Structure	Key Wells	Year Drilled	Total Depth (FT.)	GAS		OIL	
					Maximum Single Test Rate (MMCF/d)	Combined Test Rate (MMCF/d)	Maximum Test Rate (BBL/d)	Combined Test Rate (BBL/d)
Primrose	3	N-50	1972	5,622	17.4	50.5	350	650
West Sable	8	O-47 E-48	1972 1971	13,775 11,820	5.8 10.6	6.1 64.0	Trace of Oil 2,080	4,080
Cohasset	2	D-42	1973	14,521	.071	.096	1,050	1,565
Gas and Condensate (Significant Shows)							Condensate Combined Test Rate (BBL/d)	
Alma	1	F-67	1984	16,581	29.8	61.2	709	11.6
Unisacke	1	G-72	1984	18,816	20.6	26.6	150	5.6
Glenelg	1	J-48	1983	16,890	30.0	92.4	640	6.9
Arcadia	1	J-16	1983	19,701	14.1	25.0	119	4.8
S.W. Benqueveau	1	C-21	1982	16,375	19.9	20.7	100	4.8
South Venture	1	O-59	1982	20,261	18.2	93.4	3,403	36.4
Olympia	1	A-12	1982	19,888	17.5	56.0	845	15.1
Venture	5	H-22 B-52 B-43 B-13 D-23	1984 1983 1982 1981 1979	19,501 19,354 19,288 17,600 16,300	38.0 49.7 15.0 18.6 22.6	66.3 63.1 95.0 81.2 44.4	761 207 2,100 1,158 548	11.5 3.3 22.1 14.3 12.3
Intrepid	1	L-80	1974	13,651	7.6	18.1	191	10.5
Citania	1	I-59	1974	15,010	11.0	19.6	1,331	68.0
Thabaud	2	I-94 P-84	1978 1972	12,987 13,500	13.7 10.6	13.7 30.0	404 103	29.5 3.4
Eagle	1	D-21	1972	15,388	1.4	2.5		

Note: MMCF/d - million cubic ft. per day

11 Geological Survey
of Canada
estimates of
hydrocarbon
potential (1983).

Discoveries — Scotian Shelf

	Gas trillion cubic feet	Oil million barrels
Thebaud	0.4	13.8
Venture	2.0	40.2
Other Discoveries*	1.5	35.2
TOTAL	3.9	89.2

*Includes Arcadia, Banquereau, Citnalta, Cohasset, Intrepid, Olympia, Onondaga, Primrose, Sable Island & South Venture.

Potential — Scotian Shelf

	Average Expectation (50% Probability)
Gas Potential trillion cubic feet	17.9
Oil Potential million barrels	452.8

10 Map of significant
hydrocarbon
discoveries.

UNIACKE

Uniacke G-72 was drilled for Shell and partners by the *SDS Vinland* to a total depth of 18,816 feet (5 735 m). The Uniacke structure is located 12 miles (19 km) north of the eastern tip of Sable Island. The well, completed in April 1984, recorded a combined flow of 26.6 million cubic feet per day (753,232 m³/d) of gas and 150 barrels per day (23.8 m³/d) of condensate from two zones below the 17,000-foot level.

ARCADIA

The Arcadia J-16 wildcat well was drilled by Mobil and partners to a total depth of 19,701 feet (6 005 m) by the *Zapata Scotian*. It was completed in July 1983. The Arcadia Structure lies 10 miles (16 km) northeast of Sable Island. The combined flow rate from the three zones was 25 million cubic feet per day (707,925 m³/d) of gas and 119 barrels per day (19 m³/d) of condensate.

Further exploration is required to determine the potential of these new discoveries but when they are added to Venture, South Venture, Intrepid, Olympia, Citnalta, Cohasset, Thebaud, Eagle, Primrose, West Sable and Banquereau, they greatly increase the potential for future gas production offshore Nova Scotia (Figure 9).

The success of exploration drilling on the Scotian Shelf since the discovery of Venture by Mobil in 1979 is encouraging. As knowledge of the geology of the Scotian Shelf has increased, the ratio of successful wells to wells drilled has risen dramatically. Of the past 16 wildcat wells drilled, seven, or 44 per cent, have discovered significant quantities of gas, a high success ratio for the petroleum industry.

The Geological Survey of Canada (GSC) 1983 report estimates that discovered gas on the Scotian Shelf totals 3.9 trillion cubic feet (111.7 billion m³) and discovered oil totals 89 million barrels (14.2 million m³) (Figure 11). For total gas and oil reserves off Nova Scotia, GSC estimates show a 50 per cent probability that 17.9 trillion cubic feet (508 billion m³) of gas and 452.8 million barrels (72 million m³) of oil could exist in the region.



August, 1984.

5 LEGISLATION AND ADMINISTRATION

(The following applies to both offshore and onshore regions.)

The Government of Nova Scotia and the Government of Canada jointly manage petroleum-related exploration and development in Nova Scotia's offshore region, the Province through the Department of Mines and Energy and the federal government through the Canada Oil and Gas Lands Administration (COGLA) (Figure 12). Both governments enacted legislation in 1984 to govern petroleum-related activity in the offshore region. In addition, the Province amended several statutes pertaining to petroleum-related activity onshore.

12 Joint resource
management of
offshore activities.

Activity	Joint Resource Management
Posting of Lands	Federal and Provincial officials recommend to Board Board considers and approves or rejects
Exploration Agreement	
• negotiations	Federal and Provincial officials negotiate with industry Board considers and approves or rejects
• activity	Federal and Provincial officials monitor COGLA issues approvals on behalf of Board
Development Plan	Federal and Provincial officials review Board considers and approves or rejects
Production License	
• negotiations	Federal and Provincial officials negotiate with industry Board considers and approves or rejects
• activity	Federal and Provincial officials monitor COGLA issues approvals on behalf of Board

Board — Canada-Nova Scotia Offshore Oil and Gas Board
COGLA — Canada Oil and Gas Lands Administration

O F F S H O R E

13 Provincial and federal petroleum legislation.

The Nova Scotia legislation consists of three offshore and four onshore acts (Figure 13). Several of these statutes legally implement provisions of the Canada-Nova Scotia Agreement on Offshore Resource Management and Revenue Sharing signed in March 1982. The legislation, as a whole, provides a framework for the orderly exploration, development and production of Nova Scotia's offshore and onshore petroleum resources. The offshore and onshore regions to which this legislation applies are shown in Figure 14. The seven new and amended statutes of Nova Scotia are summarized in the following paragraphs.

NOVA SCOTIA		CANADA
ONSHORE	OFFSHORE	
	Canada-Nova Scotia Oil and Gas Agreement (Nova Scotia) Act	Canada-Nova Scotia Oil and Gas Agreement Act
Petroleum Resources Act	Offshore Oil and Gas Act	Canada Oil and Gas Act
Energy and Mineral Resources Conservation Act	Oil and Gas Production and Conservation (Nova Scotia) Act	Oil and Gas Production and Conservation Act
Pipeline Act		
Gas Utilities Act		

The *Canada-Nova Scotia Oil and Gas Agreement (Nova Scotia) Act* gives the necessary legislative authority to certain provisions of the Canada-Nova Scotia Agreement and supplements and clarifies certain of the Agreement's provisions, making them more effective. The resource development offshore is jointly administered by Nova Scotia and Canada through the Canada-Nova Scotia Offshore Oil and Gas Board, which became a permanent institution with legal authority under this legislation. This Board directs the activities of the Nova Scotia office of the Canada Oil and Gas Lands Administration, the federal agency designated to administer offshore oil and gas resource activities in Nova Scotia's offshore region.

The *Offshore Oil and Gas Act* defines the rights and obligations under which oil and gas activity offshore Nova Scotia is carried out. The emphasis under this Act is on active oil and gas development with close co-operation between government and industry.

The *Oil and Gas Production and Conservation (Nova Scotia) Act* governs exploration and production operations offshore Nova Scotia. The emphasis under this Act is to ensure that operations are conducted in a safe manner and that hydrocarbon resources are produced efficiently.

The *Petroleum Resources Act* (as amended) defines the rights and obligations under which petroleum activity onshore Nova Scotia is carried out.

The *Energy and Mineral Resources Conservation Act* (as amended) governs the activities related to the exploration, production and transmission of energy onshore emphasizing the safe and efficient performance of these activities.

The Pipeline Act (as amended) provides for the regulation of the transmission of oil and gas from the source to the consumer through the Province of Nova Scotia.

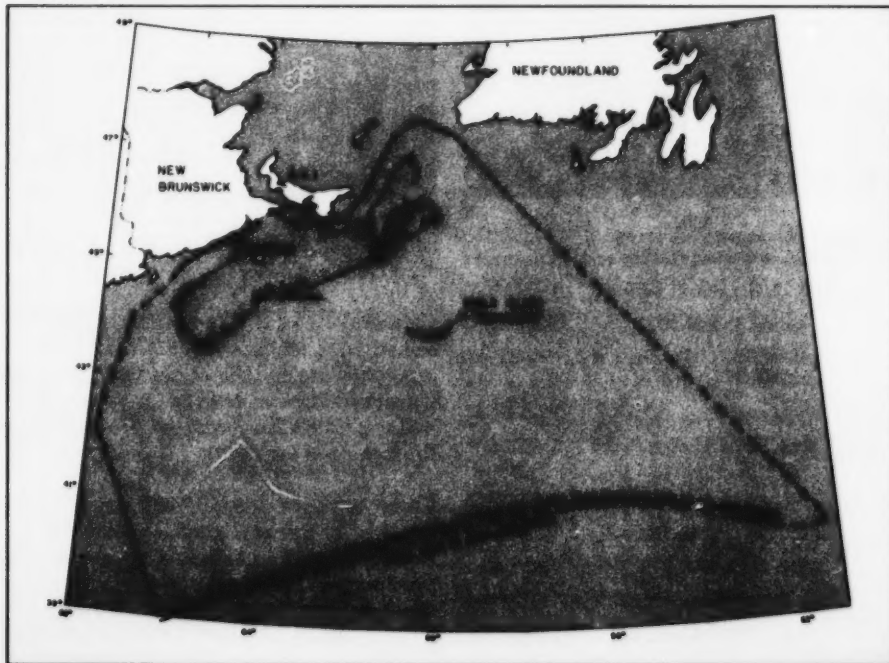
The Gas Utilities Act (as amended) deals with the establishment of fair prices and rates for gas distributed by the gas utility to the consumers of Nova Scotia.

These acts summarize the legislative framework under which petroleum exploration and development occur offshore and onshore. For the offshore region, the Department of Mines and Energy monitors and analyzes exploration and development activity. It advises the Nova Scotia members of the Canada-Nova Scotia Offshore Oil and Gas Board on key issues such as exploration agreements, provisional leases and production licenses and co-operates with COGLA and the oil industry on operational activities such as testing and safety.

For onshore petroleum resources, the Department, on behalf of the Government of Nova Scotia, administers and regulates exploration and development. It assigns and sets the provisions of leases for exploration and development projects and monitors projects to ensure they meet accepted standards of safety and performance.

The Department of Mines and Energy co-operates with other departments, industry and other private sector groups in preparing for the impact of major energy developments. The Department is responsible for the effective evaluation, promotion and control of the development and use of Nova Scotia's energy resources for the optimum economic and social benefit of the Province.

14 Nova Scotia
offshore and
onshore regions.



VENTURE PROJECT

1 OFFSHORE AND ONSHORE FACILITIES

Mobil Oil Canada Limited and its partners in the Venture Project, Petro-Canada Exploration Incorporated, Texaco Canada Resources Limited, Nova Scotia Resources Limited and East Coast Energy are currently proceeding with plans for the development of Nova Scotia's first offshore natural gas production at a cost of between 2.5 and 2.9 billion dollars.

The natural gas will come from the Venture Field, located 10 miles (16 km) east of the eastern end of Sable Island and approximately 130 miles (208 km) from the coast of mainland Nova Scotia. The Venture Field covers an area of 6,900 acres (2 792 ha). The water depth is approximately 70 feet (22 m). Recoverable natural gas reserves in the field are estimated to be between two and three trillion cubic feet (tcf) (57 and 85 billion m³) of raw gas with a predicted sales gas rate of about 360 million cubic feet per day (10.2 million m³/d). Venture natural gas is largely found in sandstones below 13,300 feet (4 054 m) and at an extremely high pressure.

It is important to remember that plans for the offshore facilities needed to produce Venture gas are changing as new seismic data and drilling results from appraisal wells provide additional information about the extent of the Venture gas reservoir. The offshore production facilities required to produce natural gas from the shallow waters of the Scotian Shelf near Sable Island will be similar to those used in the southern North Sea. The offshore facilities proposed by Mobil in a spring 1984 update of the Venture Development Plan for the development of the Venture Field and associated satellite fields show three self-contained offshore platform complexes capable of processing an average 400 million cubic feet per day (11.3 million m³/d) of raw gas. One complex will be a central facility with three steel-jacketed structures: a combination wellhead and production platform, an accommodation platform and a flare structure. The remaining two complexes will be smaller and will each consist of two structures: an integrated wellhead, production and accommodation platform and a flare structure. About 20 development wells will be drilled to produce the required volumes of gas from Venture. Cantilevered jack-up drilling rigs similar to those now drilling offshore will be used to drill these wells (see photo, facing page). The offshore processing will primarily consist of dehydration and sand removal on the production platforms prior to delivery of the gas to the offshore pipeline. Compressor facilities will be required in later years to maintain pipeline pressure as the natural reservoir pressure declines.

Gas and natural gas liquids will be transported from the offshore complexes to shore in a 30-inch (762 mm) diameter, two-phase pipeline along a route approximately 165 miles (265 km) long. The proposed landfall site is in the Country Harbour area of Guysborough County, Nova Scotia. The landfall facilities will include a slug-catcher to receive and separate the slugs of liquid that form in the two-phase pipeline.

Once onshore, the gas will be processed at a conditioning plant yielding "sales gas" and natural gas liquids. These liquids will be further processed by fractionation into saleable propane, butane and condensate products. The liquid products will be stored at the onshore processing plant and will be transported to markets by truck, rail and tanker.

The sales gas will be transported to markets in Canada and the United States through a 24-inch (610 mm) 345-mile (555 km) gas transmission pipeline across Nova Scotia and New Brunswick to the United States border near St. Stephen, New Brunswick. Natural gas consumers in Nova Scotia will be served by a local gas distribution company fed by laterals from the main transmission line. Four compression stations along the main line will be required to maintain gas pressure and transport the design gas volume of 360 million cubic feet per day (10.2 million m³/d).

The Venture Project enjoys the advantage of proximity to large markets and can be developed using proven technology.

REPRESENTATIVE JACKUP AND SEMI-SUBMERSIBLE DRILLING UNITS



ZAPATA SCOTIAN Jackup unit, three triangular legs, electro-mechanical jacking system

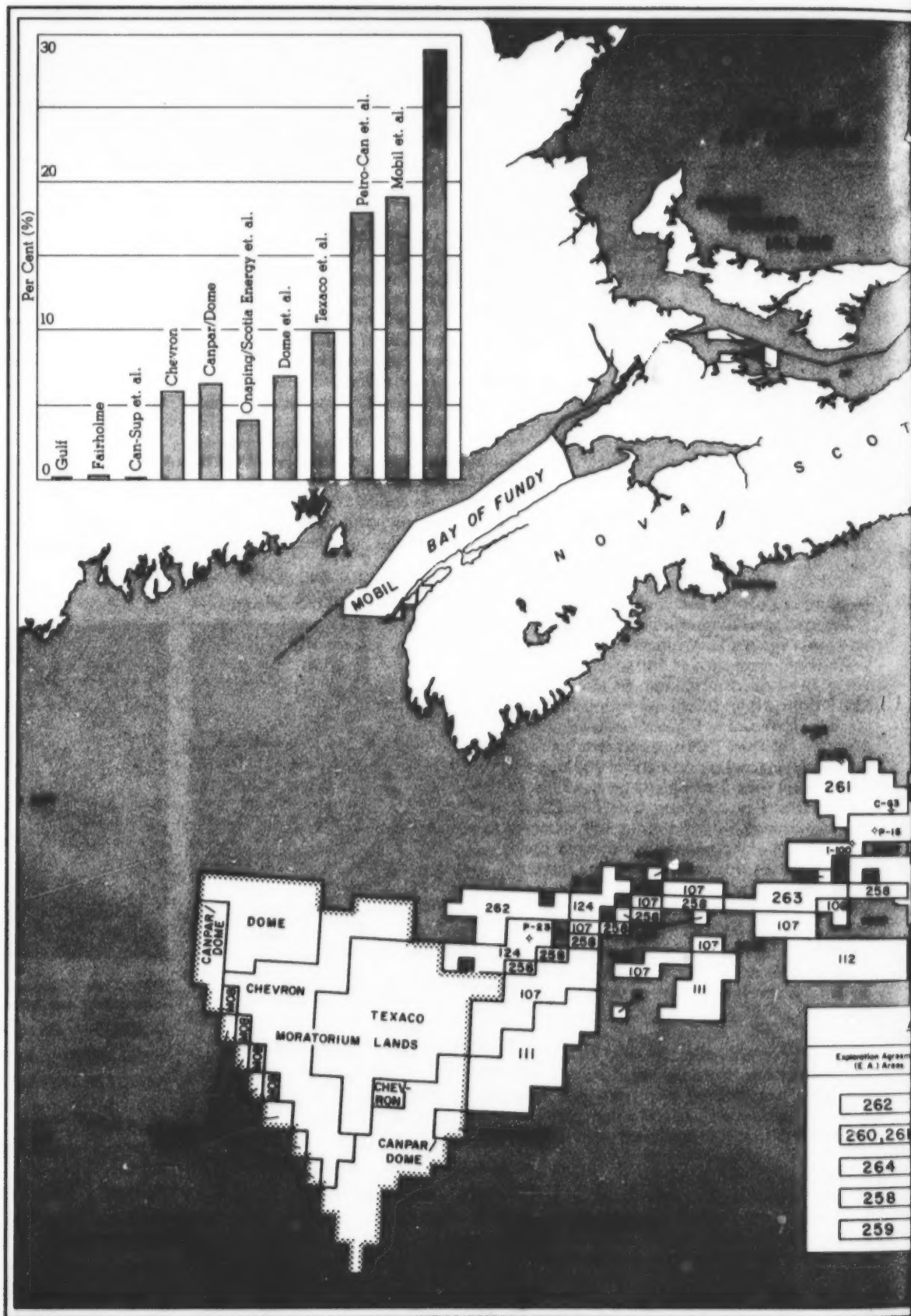
COMPANY Zapata Off-Shore Company
WATER DEPTH 200 feet (61 m)
RATED DRILLING DEPTH 25,000 feet (7 620 m)
YEAR BUILT 1981
SHIPYARD Promet Limited, Singapore
LENGTH 230 feet (70 m)
WIDTH 212 feet (65 m)
DERRICK HEIGHT 147 feet (45 m)
KEEL TO MAIN DECK 26 feet (8m)
LIVING QUARTERS CAPACITY 94

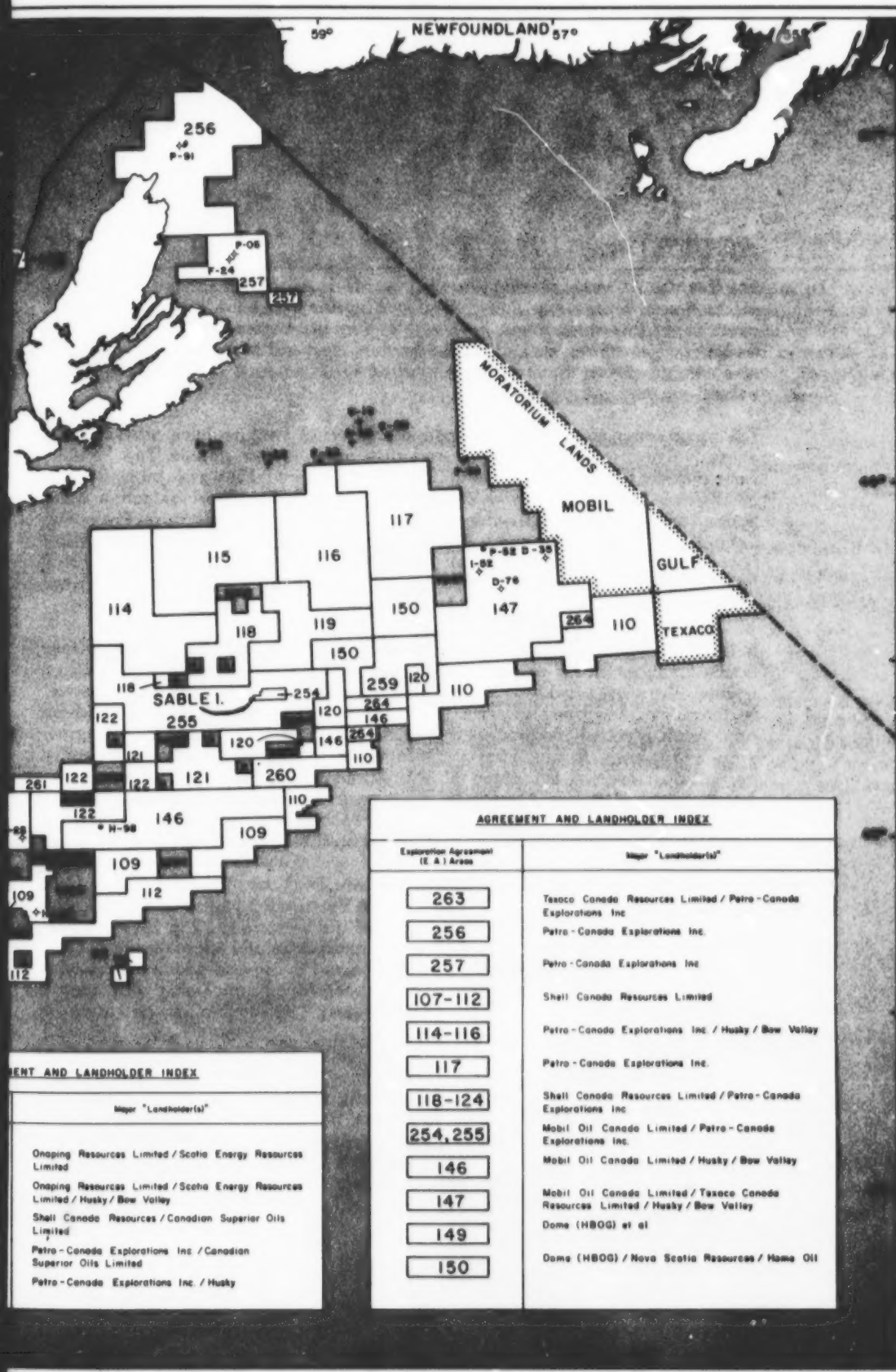


SEDCO 709 Dynamically positioned semi-submersible, twin-hulled, column stabilized

COMPANY Marine Drilling, S.A. (SEDCO)
WATER DEPTH 6,000 feet (1 829 m)
RATED DRILLING DEPTH 25,000 feet (7 620 m)
YEAR BUILT 1977
SHIPYARD Hawker-Siddeley Canada Ltd., Halifax
LENGTH 296 feet (90 m)
WIDTH 218 feet (66 m)
DERRICK HEIGHT 160 feet (49 m)
KEEL TO MAIN DECK 113 feet (34 m)
LIVING QUARTERS CAPACITY 97

15 Exploration Agreement area by major interest holder.





AGREEMENT AND LANDHOLDER INDEX

Exploration Agreement
(E.A.) Areas

Major "Landholder(s)"

263

Tasoco Canada Resources Limited / Petro-Canada
Explorations Inc.

256

Petro-Canada Explorations Inc.

257

Petro-Canada Explorations Inc.

107-112

Shell Canada Resources Limited

114-116

Petro-Canada Explorations Inc. / Husky / Bow Valley

117

Petro-Canada Explorations Inc.

118-124

Shell Canada Resources Limited / Petro-Canada
Explorations Inc.

254, 255

Mobil Oil Canada Limited / Petro-Canada
Explorations Inc.

146

Mobil Oil Canada Limited / Husky / Bow Valley

147

Mobil Oil Canada Limited / Tasoco Canada
Resources Limited / Husky / Bow Valley

149

Dome (HBG) et al

150

Dome (HBG) / Nova Scotia Resources / Home Oil

AGREEMENT AND LANDHOLDER INDEX

Major "Landholder(s)"

Onaping Resources Limited / Scotia Energy Resources
Limited

Onaping Resources Limited / Scotia Energy Resources
Limited / Husky / Bow Valley

Shell Canada Resources / Canadian Superior Oils
Limited

Petro-Canada Explorations Inc. / Canadian
Superior Oils Limited

Petro-Canada Explorations Inc. / Husky

VENTURE PROJECT

2 ACTIVITY AND UPDATE

The Venture Project is moving forward towards development and the commercial production of natural gas and natural gas liquids under the direction of Mobil, operator for the five partners involved in Venture. Exploration and delineation drilling continued during 1984 in the Venture area and Mobil began the process of obtaining regulatory approvals needed to commence development of the natural gas reserves at Venture.

The environmental and socio-economic impacts of Venture have already been extensively reviewed by federal and provincial review panels. The Venture Development Project Environmental Impact Statement (EIS) was submitted to the EIS Review Panel in March 1983, and, following public hearings across Nova Scotia, the review panel recommended approval of the Venture Project in December 1983, subject to several requirements and conditions. The project's Socio-Economic Impact Statement (SEIS) was also submitted in March 1983. Following public hearings and extensive review, the SEIS Review Panel recommended project approval in January 1984.

In January 1984, a Development Plan was submitted by Mobil to the Canada-Nova Scotia Offshore Board as one of the requirements for obtaining a production license. The plan provided detailed analysis of reservoir geology and reservoir performance, described the design and construction of offshore and onshore production, pipeline and processing facilities, and summarized project economics and Canada benefits. Time from commencement of material procurement to initial gas production was estimated at approximately three years. To support its development planning, Mobil has assembled the Venture Project Task Force, headquartered in Halifax and composed of Mobil employees and staff from the joint Venture consulting consortium of SNC/Fluor/Whitman Benn.

Five wells have been drilled on the Venture field, beginning with the D-23 discovery well completed in 1979 (Figure 16). Venture B-13 followed in 1981, then Venture B-43 in 1982, Venture B-52 in 1983 and Venture H-22 in 1984. The two wells drilling in mid-1984 on recently discovered structural anomalies at Venture are the sixth and seventh wells and are expected to provide additional reserves necessary to proceed with the Venture Project. Mobil anticipates submitting a revised development plan in late 1984 or early 1985 to include new data on reserves, cost and economics.

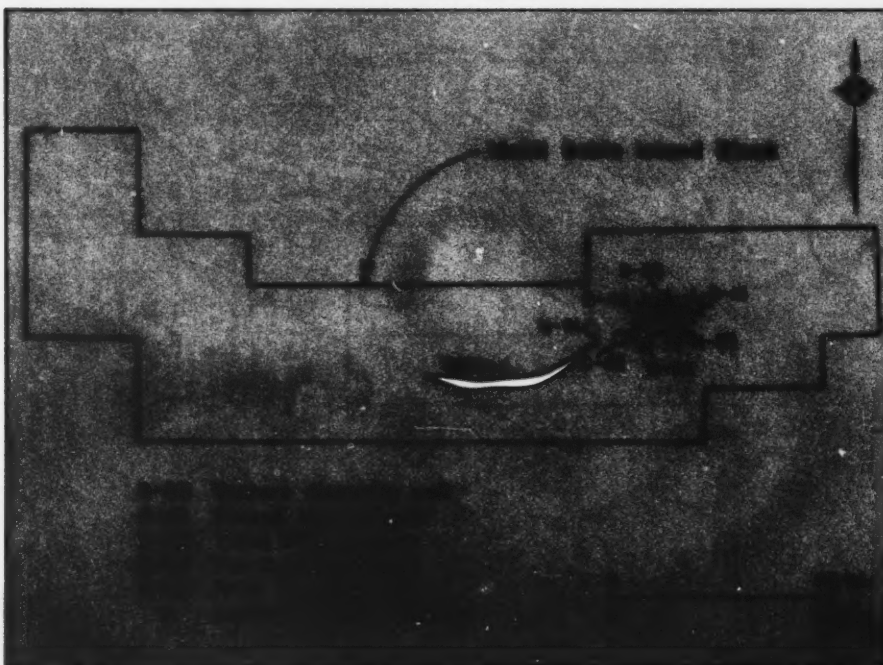
Once onshore and processed, the natural gas must be transported to waiting markets. Both Mobil and Sable Gas Systems, a company formed in 1983 by TransCanada Pipelines Limited and Nova Scotia Resources Limited, have expressed interest in constructing and operating the gas transmission system across Nova Scotia and New Brunswick to the United States border. Sable Gas Systems is conducting preliminary engineering and route surveys in preparation for submission of an application to the National Energy Board to build the pipeline system.

The timing of delivery of the first natural gas from Venture depends on the completion of a series of important steps. Facilities offshore and onshore Nova Scotia, export of natural gas from Canada, import of Venture gas into the United States and the construction of gas transmission systems in both countries will all be subjected to review by regulatory agencies. The major events which will occur as Venture proceeds towards development include:

- Completion of Delineation Drilling
- Revision of Venture Development Plan Submission
- National Energy Board Export Application
- National Energy Board Pipeline Application
- Economic Regulatory Administration Application (U.S.)
- Federal Energy Regulatory Commission Application (U.S.)
- Procurement of Project Materials and Offshore Construction
- Onshore Facilities Construction
- Initial Gas Production

Final delineation drilling and the completion of a revised development plan are expected in late 1984 or early 1985. The approval of regulatory agencies will be sought in 1985-86. Construction of project facilities following approvals is estimated to take approximately three years. The offshore component will be started first and construction of onshore facilities will begin shortly thereafter. Initial gas production is expected in 1989.

16 Venture area well locations.



August, 1984.

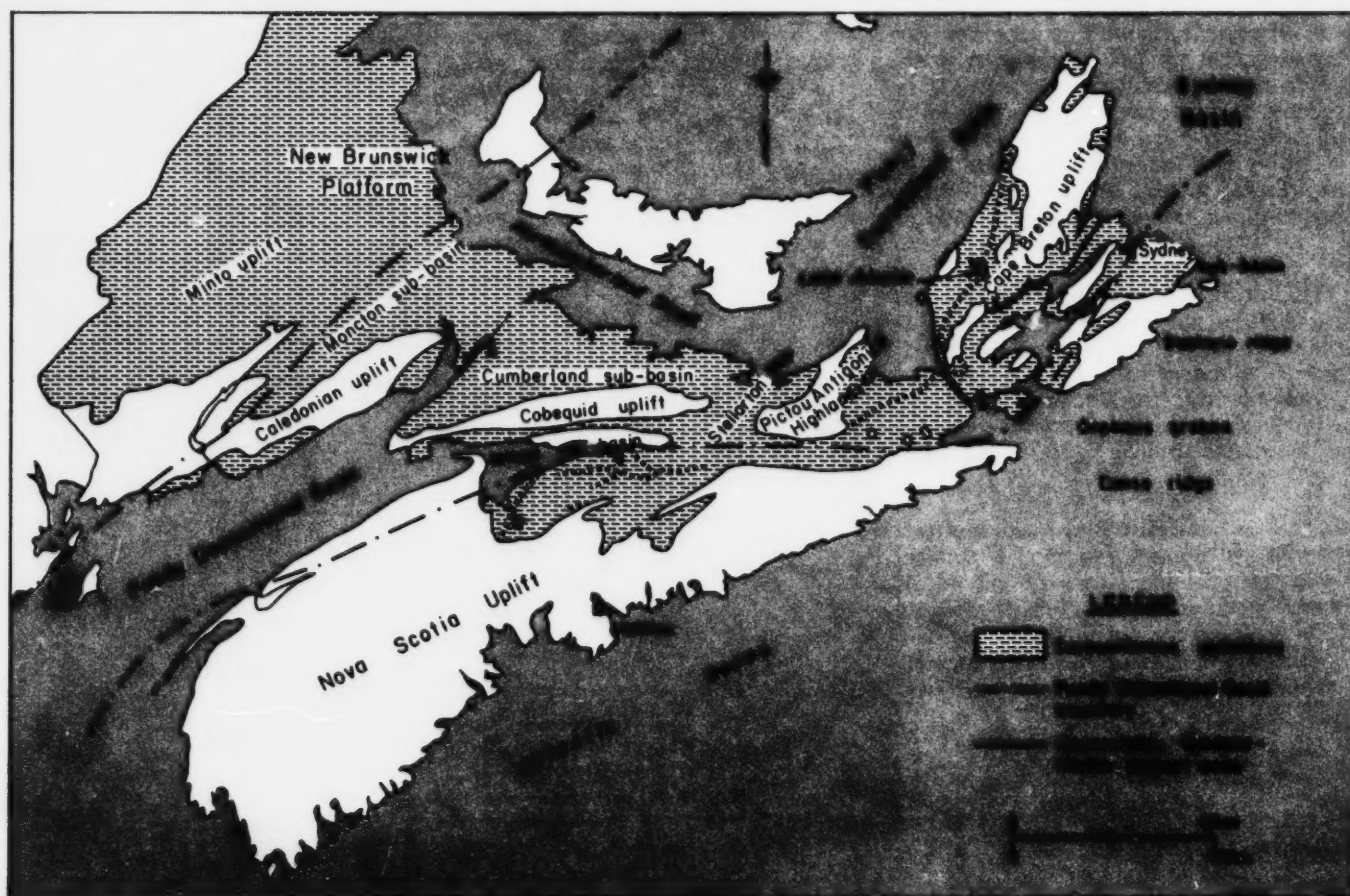
ONSHORE

1 GEOLOGICAL SETTING

The existence of widely scattered traces of oil in the form of seeps at Lake Ainslie, Inverness County, and asphaltic material in the marine Windsor Group with pyrobitumen in the non-marine Horton, Stellarton and Pictou Groups, known since the 1800s, has prompted various exploration programs.

The search for petroleum is restricted to the Carboniferous aged rocks because the older rocks were subjected to metamorphism and, as a result, have virtually no petroleum potential. Early Carboniferous aged rocks are found in several sedimentary basins, including the Minas Basin, Cumberland Basin, Stellarton Gap-Pictou Basin, Antigonish Basin, and Inverness-Mabou Sub-basin (Figures 17 & 18).

17 Carboniferous Age
sediments onshore
Nova Scotia.



Carboniferous sediments were deposited in narrow elongated basins, bordered by uplands in central and southern New Brunswick to the northwest and by an uplifted region of pre-Carboniferous rocks in Nova Scotia to the south. The first sediments were deposited in the Fundy Depositional Basin and came from both bordering areas. These sediments form the Horton Group, and consist of red to grey sandstone, conglomerate, siltstone, and shales.

Within the Horton Group in New Brunswick, at Stony Creek in the Moncton sub-basin, the Albert Formation contains a commercial oil and gas field. It has produced 28 billion cubic feet (793 million m³) of gas and 800,000 barrels (127,192 m³) of oil since its discovery in 1909 (figures to 1979). Gas production was 90 million cubic feet (2.5 million m³) and oil production 4,750 barrels (755 m³) in 1979.

Overlying the Horton Group is the Windsor Group which consists generally of thick members of massive to poorly bedded red and greenish-grey mottled siltstone, shale and sandstone interbedded with gypsum, anhydrite, shale and thin tabular sequences of limestone and dolomite.

Deformation by folding and faulting accompanied by volcanic activity during or after deposition of evaporites, produced salt flowage in some of the basins and accounts for the thick accumulations in salt domes, diapirs and ridges. In between, carbonates, clastics and minor evaporites were deposited in marine, shallow marine and continental environments.

18 Geological time scale onshore Nova Scotia.

ERA	PERIOD / EPOCH		GROUP
P A L E O Z O I C	245 Mo	PERMIAN	
	286 Mo	C A R B O N I F E R O U S	PICTOU (and STELLARTON)
			CUMBERLAND
			RIVERSDALE
			CANSO
			WINDSOR
			?
	360 Mo	D E V O N I A N	HORTON
		LATE	
		MIDDLE	
	408 Mo		BASEMENT COMPLEX

Mo = Millions of years before present.

O N S H O R E

The Canso Group lies above the Windsor Group and is mainly an offlap sequence containing thinly laminated red and grey shale, sandstone and minor limestone.

During deposition of Riversdale Group rocks, thick deposits of coarse clastics (red and grey sandstone and shale), non-marine red and grey sandstone, siltstone, shale and coal were deposited.

The Cumberland Group contains appreciable amounts of coal. The Group lies unconformably on other Carboniferous and older rocks, and consists of non-marine red and grey conglomerate, sandstone, shale and mineable coal seams.

When the upper part of the Cumberland Group was being deposited, non-marine fluvial and fluvio-lacustrine red and grey sandstones, shales and minor conglomerates of the Pictou Group were deposited in other areas. These Pictou sediments unconformably overlaid older Paleozoic rocks and onlapped the older metamorphic rocks of the basement. Western Cape Breton Island, Sydney Basin, Stellarton Gap and Minto Uplift were swamp areas where thick coal deposits accumulated.

In the Late Carboniferous, swamps flourished. Pyrobituminous material, in part of algal origin, formed. Small amounts of gas and minor oil staining reported in the various rock units are in interbedded sandstones and may have originated from the decomposition of plant material.

The main potential for hydrocarbons in the Carboniferous rocks depends on good local porosity, the migration of hydrocarbons from the underlying Horton and Windsor Group rocks, and hydrocarbons in association with coal bearing horizons. Movement of Windsor Group salt has probably produced a variety of traps in post-Windsor sediments flanking and overlying high relief diapirs in some areas.

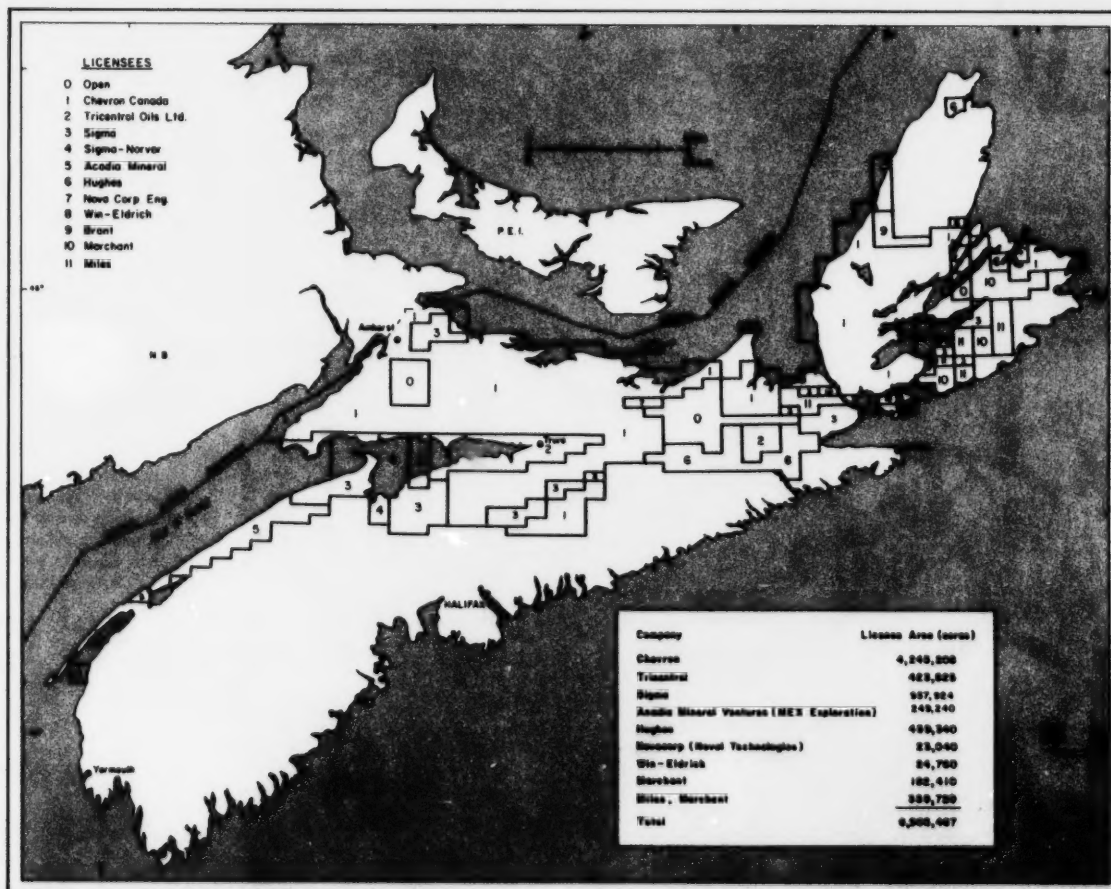
2 EXPLORATION ACTIVITY

The Northern basinal areas of Nova Scotia have, and continue to be, the focus of oil and gas exploration onshore and the bulk of currently held exploration licenses are concentrated in these areas. In 1984, exploration licenses for approximately 6.9 million acres (2.8 million ha), representing about one-half of the province's land mass, are held by a total of six exploration companies and four private individuals (Figure 19).

Exploration for hydrocarbons in the province began in the mid-1800s when surface seeps, oil-filled cavities in gypsum, and petroliferous sandstones were discovered in several counties.

Various drilling programs have provided wells which have encountered shows of subsurface natural gas and oil. None of the discoveries has been commercial, although there is a report of approximately 100 gallons of oil from a hole near MacIsaac Point at Lake Ainslie in 1874.

19 Onshore license area by landholder.



O N S H O R E

Since drilling began in 1869, approximately 117 wells with petroleum significance have been drilled onshore. The onshore wells were largely confined to the Cumberland and Stellarton Gap-Pictou Basins, Lake Ainslie and Bras D'Or Lakes areas, situated more or less in the northern portion of the province.

The major onshore activity during the past year was the commencement of a drilling program by Corkan Engineering of Canada Ltd., the first onshore drilling program since the Scotsburn No. 2 well, which was completed in November 1981, in Pictou County. Corkan farmed into Sigma Resources, Inc. and M.J. Miles *et al* lands situated in the Strait of Canso area. Two wells out of an approved 10-well program have been completed to date to final depths and four additional wells were spudded. This program has been subsequently cancelled due to Corkan's financial difficulties.

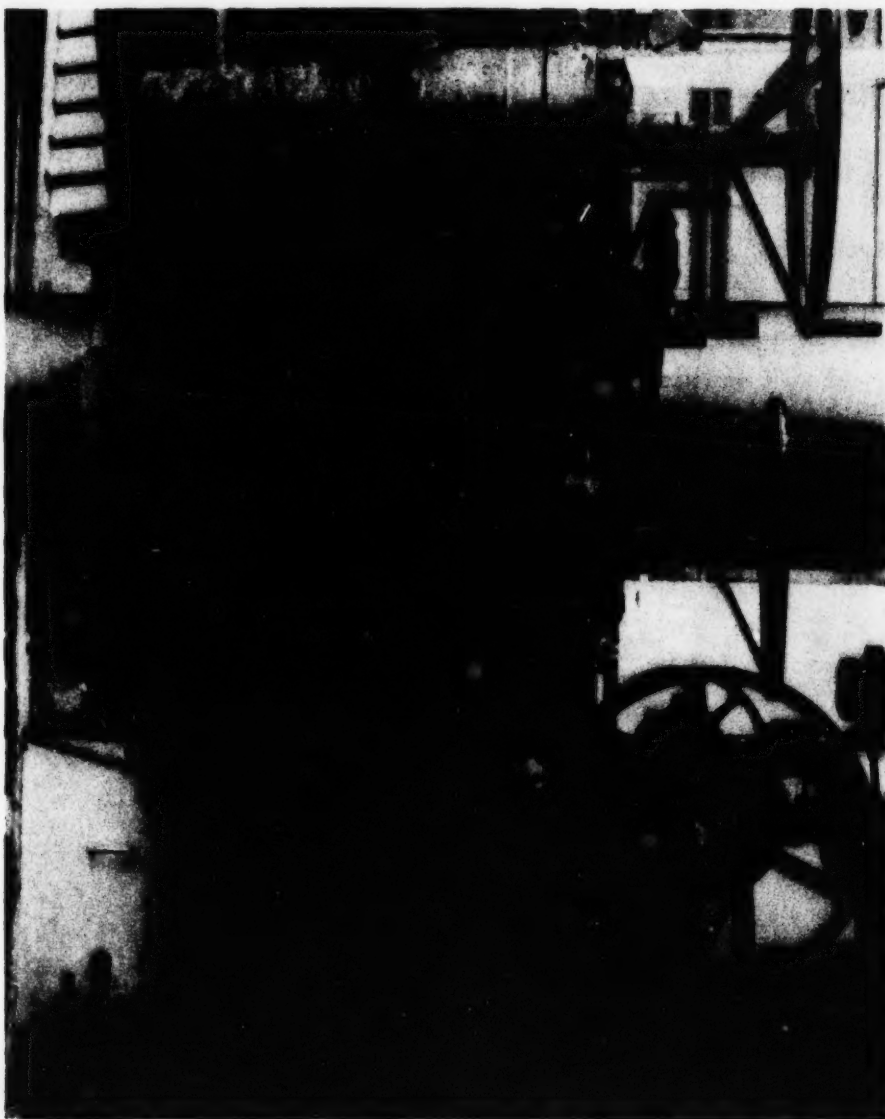
Chevron, the largest license holder onshore, has reviewed its data from the Minas Basin, Cumberland Basin and Cape Breton Blocks and is currently re-assessing the potential of these areas. Several license holders conducted interpretive studies work on their licenses. Plans are being made by Sigma, Tricentrol, and Acadia Minerals Ventures to shoot seismic programs over their licenses in 1984. This could result in drilling programs in future years.

PART II

PETROLEUM INFORMATION

The following sections take a look at the major areas of an exploration program, describing certain aspects of the petroleum exploration techniques and equipment currently in use offshore Nova Scotia.

Choke manifold consisting of a series of valves and chokes used to control the flow of fluids from an offshore well.



EXPLORING FOR OIL AND GAS

1 THE GEOPHYSICAL SURVEY

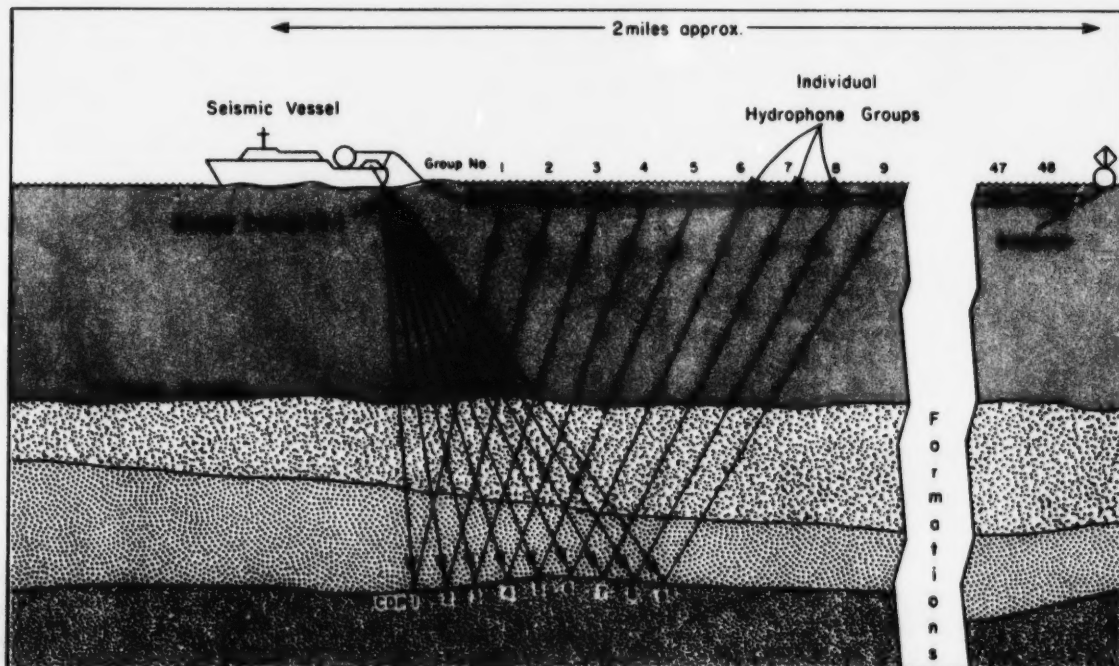
The drilling locations of exploration and delineation wells on the Scotian Shelf and Slope are primarily determined from the results of seismic data, which help to map a picture of the subsea geology. Seismic plays a very important role in determining well locations in this area because the region is relatively undrilled [one well per 250,000 acres (101 175 ha)], which means that data from a large number of wells is not available to help form a detailed picture of the geology.

Exploration companies acquired 23,153 miles (37 260 km) of seismic on the Scotian Shelf and Slope in 1983. To mid-July 1984, approximately 3,181 miles (5 120 km) of seismic data have been shot. The data is processed by computer and interpreted to obtain geological models, which aid in determining the hydrocarbon potential in this region. The geophysical information obtained was to subsea depths of 25,000 feet (7 620 m).

Seismic data is acquired using a system consisting of three main components: an energy source, an array of detectors, and a recording instrument (Figure 20). The air gun is the most common energy source used offshore Nova Scotia. The energy source is actually an explosive release of air, created by a piston in a chamber, that is vented into the water. Hydrophones are pressure sensitive sound detectors that receive reflected signals from the air guns.

Seismic surveys are the result of many individual readings taking in sequence and recorded by computer onboard the survey ship. A survey begins with a source, designated s_1 towed behind the ship generating sound energy, which is reflected from certain geological markers below the seafloor. These reflections are detected

20 Diagram of typical geophysical survey.



by the 48 (in our example) groups of hydrophones and recorded on the survey vessel. The raw data recorded on magnetic tape is converted to a final processed section through a sequence of computer programs. These final sections contain seismic reflections which are interpreted with the objective of preparing contour maps indicating the distance (in time or depth) from a series of geological features called reflectors that are identifiable on the seismic sections. Interpretation starts by inspecting seismic lines which are shot through existing wells. The data from these wells give a useful geological picture, but also show where strong seismic reflections might be expected. The next stage is to examine briefly the entire survey and interpret the lines most easily interpreted, identifying the major geologic structures across the area and marking the main faults. Next those reflections whose identities are known from well data are marked on the seismic sections (Figure 21). Information is now extracted from the seismic sections and is plotted on a base map.

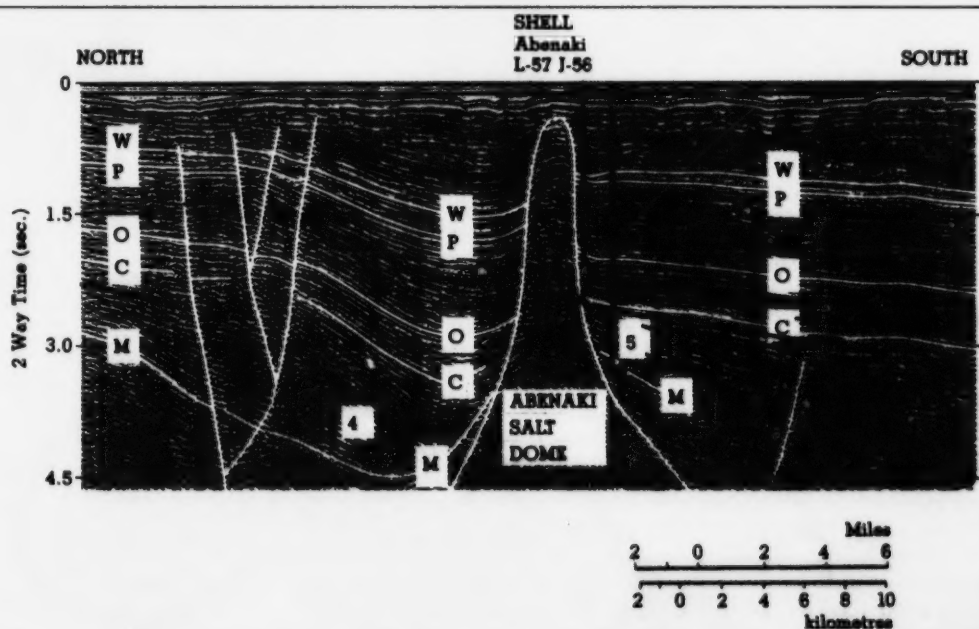
This map is used to plot subsurface information from the seismic lines and to produce a final contoured map. The final map integrated with the well information will be used to indicate any hydrocarbon potential in this area. Exact geographical locations of these positions can be fixed using radio position-fixing or integrated satellite navigation. An ever increasing proportion of seismic surveys are now located using integrated satellite navigation systems.

Typical costs for an offshore seismic program are in the range of \$745 per mile (\$1,200 per km) for data acquisition and processing. An average program might consist of 620 miles (1 000 km) although 2,485 to 3,725 mile (4 000 to 6 000 km) programs are not unusual.

21 Seismic data showing geological markers.

Seismic section from the central Scotian Shelf to the Abenaki Basin, showing a shallow salt piecemeal structure. Vertical lines at left and bottom right represent structural faults. Horizontal lines represent changes in geological formations and rock type. (Bulletin of Canadian Petroleum Geology, Vol. 25, No. 1, 1977.)

W TOP WYANDOT
P PETREL LST.
O "O" MARKER
C TOP CARBONATE
M MISAINI SHALE
— OTHER PRIMARY



EXPLORING FOR OIL AND GAS

2 OFFSHORE DRILLING UNITS

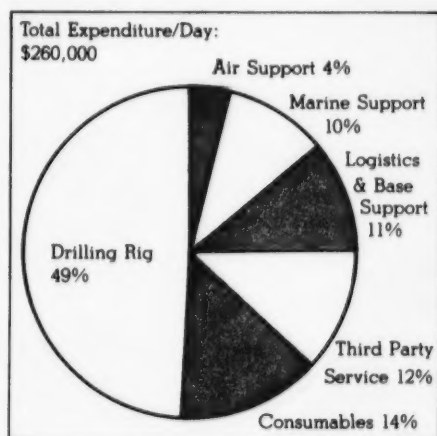
Although there are numerous types of offshore drilling units, the most common on the Scotian Shelf are the enhanced jackup rig and the semi-submersible.

The jackup rig is designed to operate in shallow water, generally less than 425 feet (130 m) deep. This permits them to drill over most of the Scotian Shelf. Jackup rigs are very stable drilling platforms. They are supported by the seabed and are not subjected to the heaving motion of the sea as are semi-submersibles. They have a barge-like hull which may be ship-shaped, triangular, rectangular, or irregularly shaped, supported on a number of lattice of tubular legs. When the rig is under tow to a drilling location, the legs are raised, projecting only a few feet below the deck, and the structure behaves like a cumbersome floating box; hence it can be towed only in good seas and at a slow speed. Upon reaching its location, the legs are lowered by electric or hydraulic jacks until they penetrate the seabed and the deck is level, some 60 feet (18 m) or more above the waves. The jackup rigs presently working on the Scotian Shelf have three legs. The legs are jettied into the ocean floor to ensure good support. Also, the legs are designed or modified to withstand the most severe environmental conditions which can reasonably be expected on the Shelf. The derrick on most jackup rigs on the Scotian Shelf is cantilevered over the side. Due to lower construction costs of a jack-up, the leasing costs are generally lower for this type of rig than a semi-submersible. (Jackup ranges from \$90,000-\$120,000/day; semi-submersible from \$150,000-\$190,000/day) (Figure 22).

Semi-submersible are floating drilling rigs consisting of hulls or caissons which carry a number of vertical stabilizing columns and support a deck fitted with a derrick and associated drilling equipment. Semi-submersible drilling rigs differ principally in their displacement, hull configuration, and the number of stabilizing columns. All the semis currently working on the Scotian Shelf have a rectangular deck. Their hull arrangement consists of a pair of parallel rectangular pontoons which may be blunt or rounded and house thrusters for position-keeping or self-propulsion, although some have individual pontoons or caissons at the foot of each stabilizing column or pair of columns. Eight columns (four stabilizers and four intermediate columns) is a common arrangement as are three and six columns, and both hulls and columns are used for ballasting as well as storing supplies. The semi-submersible is very stable because, when the hull is ballasted down, the center of gravity is low in the water and the columns offer a small area to be affected by wave action. It can operate in deeper water than a jackup rig. Operational depth is limited principally by the mooring equipment and by riser handling problems, so most semi-submersibles have a limit of about 656 feet (200 m). However, some units have a capability of drilling in 6,562 feet (2 000 m) of water with the aid of "dynamic positioning". This is a method of maintaining the position of a vessel with respect to a point on the seabed by activating on-board propulsion units in response to signals received from a position-error detector. This method of automatic station-keeping is often computer-controlled.

Both jackups and semi-submersibles operating on the Scotian Shelf meet all of the latest standards required for operating in harsh environments.

22 Average offshore drilling expenditures.



3 DRILLING OPERATIONS

Drilling a well three or four miles below the seabed (the deepest well on the Scotian Shelf is S.W. Banquereau F-34 drilled to 20,700 feet [6 309 m] in 1983) may take anywhere from six to nine months, depending on depth and conditions encountered. Wells are drilled differently, depending on whether a jackup or semi-submersible drilling rig is used. A typical well drilled to 18,000 feet (5 486 m) using a semi-submersible rig costs in the range of \$50-\$60 million dollars.

Wells drilled by jackup rigs begin with a conductor pipe, 26 to 30 inches (66 to 76 cm) in diameter, which is driven 100 to 300 feet (30 to 100 m) into the seafloor. Cement is then placed between the pipe and the hole. A drill bit cuts a hole about 22 inches (55 cm) in diameter to anywhere between 1,000 to 2,000 feet (300 to 600 m) deep. A pipe is lowered into the conductor pipe and down the hole and cement is forced between the new section of pipe and the wall of the hole. This pipe is called casing. A blowout preventer stack is installed beneath the rig floor to contain hydrocarbon pressures that may be encountered in further drilling. The hole is then deepened and more casing of smaller diameter may be cemented into place.

Wells drilled by a semi-submersible begin with a large diameter hole drilled into the seafloor. The conductor pipe is then lowered into the hole and cemented in place. Following further drilling, setting and cementing of casing, the blowout preventer stack is installed on top of the wellhead on the ocean floor. A marine riser pipe is then installed on top of the blowout preventer. Drilling now takes place through the marine riser pipe, which isolates the wellbore from water, functions as a guide for the drillstring and carries the drilling mud and cuttings from the hole to the rig.

Drilling muds are required during the drilling operation. This mixture of water and various additives is circulated down the inside of the drill pipe, through the drill bit and up the outside of the drill pipe to the surface. The mud system continuously cleans the hole by carrying the rock cuttings back to the surface and lubricates the drill bit. The mud and cuttings are screened and separated so the mud may be used again and samples collected. One of the more important mud properties, particularly where areas of high pressure are expected as in the geopressured area around Sable Island, is the mud weight. The column of mud must be able to "hold back" formation pressures encountered as the hole is drilled. The mud actually replaces the rock drilled out in this regard in holding back pressure. If the mud weight is too low, formation fluids (water, gas, oil) can flow into the well bore causing a "kick". A continuous uncontrolled entry of fluids is referred to as a "blowout". The formation fluids initially force the drilling muds out of the hole and then continue to flow until checked. Overpressured zones may be intersected with little warning. The drilling mud is, therefore, continuously monitored. Drilling crews continuously train and conduct drills for blowout operational procedures to minimize their reaction times.

Several procedures are used to evaluate the well as it is being drilled besides continuous monitoring of the mud for traces of oil and gas. Downhole logs are one of the most important tools in this regard. Logging tools are lowered into the well on the end of electrical wirelines to measure various physical properties of the formation rock and fluids. Valuable information is obtained about lithology, porosity, permeability, and producibility. In order for formation rocks to be of good quality for a hydrocarbon reservoir, they must be of a certain rock type (lithology)

EXPLORING FOR OIL AND GAS

contain openings in which petroleum can exist (porosity) and contain openings which are connected so that the hydrocarbons can be produced (permeability). Gas, oil and water can be differentiated and the relative percentages of each inferred. The main logging tools used acquire information on the electrical, nuclear and acoustic properties of the formation rocks and fluids. These logs are used extensively to correlate and evaluate formations between nearby wells and, therefore, help in the interpretation of the geology of a given area. Downhole logs are also used for operational and engineering purposes. For example, the quality of the cement job, where the cement is used to bind casing to the hole wall, can be deduced, formation fractures can be located and the setting depth for future operations such as testing can be selected.

At various sections of the hole, and particularly in potential producing zones, in-situ core samples may be taken to provide more detail than can be derived from cuttings. The two basic types of coring are conventional coring (at the time of drilling) and sidewall coring (after drilling). Conventional cores are generally from 2 to 5 inches (5 to 13 cm) in diameter and 60 feet (18 m) in length. They are a reliable source of data for such factors as porosity and permeability. Sidewall coring is accomplished with a wireline tool which fires a projectile (hollow bullet) into the wall of the hole. The projectile is pulled out providing a small core sample. During one run many of these cores can be obtained.

Drill stem tests are conducted upon evaluation of the logs, cores and cuttings to obtain information on the liquids and pressures in a formation. The test interval is sealed off to allow formation fluids to flow into the hole and up the drill pipe. This provides fluid flows which indicate the amount of hydrocarbons that may be expected if the well is eventually developed. Drill pipe is used to lower the testing tool assembly. This consists of packers or sealing elements, valves, pressure recorder charts, and various bypass ports and circulating tubing. The monitored flow rates, when analyzed with the pressure data, can indicate the type and amount of hydrocarbons as well as provide data indicating the extent of the producing reservoir.

Various wireline formation tests can also be employed, to enable fluid sampling and the evaluation of fluids, pressures and permeabilities. Samples are generally between approximately one and five gallons. These tests are conducted with the full fluid column in the hole and are therefore faster and safer than drill stem tests, but do not provide the same quantity or quality of data.

If a well is deemed to be a discovery, additional delineation wells are drilled to define the magnitude of the reservoir structure. Of prime importance is information on the relative locations of hydrocarbons and water within the reservoir. Additional chemical and physical data is required to define the total amount of production expected and the most effective locations for production wells. Studies are conducted to determine the number of wells the reservoir will support, their spacing, and the required production infrastructure. For example, due to the location of the Venture D-23 discovery well in the Venture field, four additional delineation wells were required to provide better information as to the field orientation and size as well as depths to productive horizons.

4 OIL AND GAS PLAYS

Oil and gas accumulations have been sought on the Scotian Shelf in reservoirs formed by down-to-basin faults, carbonate banks, and reefs, salt-related structures, and basement blocks. Reservoirs have high and low points as they follow the shape of underlying rock layers. Drilling locations are more precisely determined by locating features such as faults, domes, banks or reefs.

The most consistent, and so far most successful, exploration play has been found along the down-to-basin fault structural trend in the Sable Sub-basin.

The most productive targets appear to be the sandstone reservoirs created by these structural faults in the Missisauga and MicMac formations, where the sections are predominantly overpressured by the weight of strata above. The precise causes and limits of the overpressuring phenomenon are not clearly understood, but appear related to very rapid deposition of thick accumulations of source rock and reservoir rock units. The overpressured units typically have much higher porosity.

The potential of these overpressured zones was amply demonstrated with the drilling of the Venture D-23 discovery well in 1979. Most of the drilling subsequent to this discovery has been directed toward high-pressured reservoirs. It is interesting to note that the first well ever drilled offshore Nova Scotia, Mobil Sable Island C-67 (rig release January 1968), encountered an overpressured zone.

Early exploration on the east coast concentrated, however, on basement blocks, carbonate banks and reefs, and salt-related features identified by strong seismic reflections.

Salt swells, salt pillows, salt domes, and salt diapirs (piercement features) provided the focus for considerable drilling in the early to mid-seventies. Structural features created by, and resulting from, these salt features had proved to be profitable drilling targets in other parts of the world. Many wells were drilled into rock layers at the crest and along the flanks of the salt-cored features. Such gas discoveries as Primrose ('72), Onondaga and West Sable ('71) are related to salt piercement features. Others such as Eagle ('72) and Intrepid ('74) are deep-seated salt features.

Drilling of basement-related features, found underlying the Erie, Wyandot and Naskapi wells drilled in 1970-71, gave traces of oil. Some heavy, tarry oils were recovered. The MicMac J-77 well ('70) produced lighter gravity oils from beds overlying a basement feature. Follow-up drilling has shown the basement feature targets to have limited potential. Wells drilled at Erie, Crow, Fox, Naskapi, Moheida, Oneida, Ojibwa, Mohawk, and Montagnais during the early and mid-1970s were unsuccessful.

The carbonate banks, identified by seismic provided another type of drilling target. The existence of thick sections of porous limestones similar to those drilled on the prairies were hoped for. The Mohican ('71/'72), Moheida ('76/'78), Oneida ('69/'70), Demascota ('74), and Cohasset D-42 ('75) wells did not produce any shows of gas or oil from the carbonate interval.

The most common reservoirs on the Scotian Shelf are clean, fine to coarse-grained sandstones of the Lower Missisauga-MicMac formations which have porosities averaging 12-15% in normally-pressured regimes. The same sands, where overpressured, have porosities in the range of 15-22%. Individual deltaic sands of

EXPLORING FOR OIL AND GAS

the Missisauga may attain thickness of 250 feet (75 m) with an average of approximately 65 feet (20 m). Productive sands in the Venture field range, however, from 15 to 80 feet (5 to 25 m) with an average of approximately 40 to 50 feet (12 to 15 m).

Natural gas is the predominant hydrocarbon discovered on the Scotian Shelf. Figure 23 presents a representative analysis of a fluid recovery for the Sable area, indicating the relative abundance of the various hydrocarbons. The percentages of the hydrocarbons will vary from well to well and from zone to zone within the same well. The variance amounts to approximately 5% of the individual proportions listed in Figure 23. No data are given for oil due to the complexity of the compounds and the relatively small amounts of true oil in the Scotian Shelf wells.

The paucity of significant amounts of oil raises the question of why natural gas predominates. Hydrocarbons are generated by the decomposition of organic material. The kinds of hydrocarbons produced are essentially a function of the kinds of organic material available and the time and temperatures involved. Land-sourced (terrigenous) materials require more time and higher temperatures after burial to produce hydrocarbons than does the organic material derived from a marine environment. In addition, terrigenous material is essentially gas prone. Analyses indicate the bulk of the source rock organics which provide hydrocarbons to the reservoir rocks of the MicMac and Missisauga Formations originated on land. In addition, these land-sourced sediments were not exposed to the very high temperatures necessary for complete maturation. As a result, the hydrocarbons produced are a mixture of gas, condensate and possibly some light oil; or they occur as wet gas. Wet gas is a mixture of hydrocarbons in which sufficient liquid portions exist to require removal before they can be put in a pipeline.

The hydrocarbons from the Sable-Venture area, then, are principally natural gas with such amounts of other liquid hydrocarbons that require removal for processing at the landfall end of a pipeline. The gas from this area is typically "sweet gas" which means it is fortunately not contaminated with hydrogen sulphide. This compound, which is found in many Western Canadian gas deposits, is highly corrosive and creates additional expenses and difficulties in processing and transportation when present.

The significant amount of condensate associated with the Scotian Shelf hydrocarbons is an added bonus in that it provides the basis for other marketable products.

23 *Representative analysis of fluid recovery from Sable area.*

Natural Gas	Methane	89%
	Ethane	5%
	Propane	1%
Natural Gas Liquids	Butane	1%
	Condensate	2%
Contaminants	Nitrogen, CO ₂ , etc.	2%

APPENDICES

1 DEFINITIONS

Argillaceous rocks	are a group of sedimentary rocks, commonly consisting of clay, shales, mudstones, siltstones, and marls.
Carbonates	are sedimentary rocks that are primarily composed of calcium carbonate (limestone) or calcium magnesium carbonate (dolomite). Sometimes petroleum reservoirs are made up of carbonate rocks.
Clastics	are sedimentary rocks that are composed of fragments of pre-existing rocks. Sandstone is a clastic rock.
Condensates	are hydrocarbons that condense to form liquids at the surface due to reduced pressure and temperature. Such compounds actually exist in a gaseous state in the reservoir. These liquids may be colorless or have red, yellow, blue or green shades. Others are indistinguishable from very light crude oils. Condensates usually include such compounds as pentanes (C_5H_{12}) and some of the heavier hydrocarbons.
Conglomerates	are a type of rock consisting of rounded or subrounded fragments from beaches, flood plains, etc., which have become cemented together.
Crude oil	varies greatly in its properties and composition. Generally, the term is used to describe those hydrocarbons produced at a well which are liquids at the surface and are also in liquid state in the reservoir.
Fluvial	is a term used to describe being found in or produced by a river.
Fractionation	is a process of separating liquids or gases by using the differences in their boiling points.
Geopressured	is the abnormally high pressure exerted by some subsurface formations. An example is the geopressured sandstones in the Sable Basin on the Scotian Shelf.
Hydrocarbons	are organic compounds composed of carbon and hydrogen, which exist in a great variety of compounds. Petroleum is a mixture of many different hydrocarbons.
Lacustrine	is a term used to describe being found in or produced by a lake.
Natural gas ("gas")	refers to these lighter hydrocarbon compounds which, at surface temperature and pressure conditions, are in a gaseous state. These typically include such compounds as methane (CH_4), ethane (C_2H_6), propane (C_3H_8), and butane (C_4H_{10}).
Permeability	is a measure of the ease with which fluids can flow through a porous rock, the fluid conductivity of a porous medium.
Physiography	is the description of the features and phenomenon of nature.
Porosity	is the amount of void space in a rock (which can contain fluids) and is measured as a percentage of the rock volume.
Stratigraphy	is a branch of geology concerned with the study of the origin, composition, distribution, and succession of rock strata (beds of rock).
Topography	is the science of drawing maps, charts, and otherwise the surface features of a region, including hills, rivers, roads, etc.

A P P E N D I C E S

2 DIRECTORY OF OFFSHORE WELLS

Data on recent and current wells are subject to minor change.
Data current to July 31, 1984.

ABBREVIATIONS

RT	Rotary Table
KB	Kelly Bushing
GL	Ground Level
P & A	Plugged and Abandoned
P & S	Plugged and Suspended
TD	Total Depth
TS	Temporarily Suspended

WELL SYMBOLS

○	Drilling
✧	Plugged and Abandoned
✧	Significant Gas
✧	Gas Show
●	Significant Oil
✧	Oil Show
✧	Significant Oil and Gas
✧	Oil and Gas Show

WELL NAME	LATITUDE LONGITUDE	DRILLING UNIT	SPUD DATE RIG RELEASED	RT ELEVATION WATER DEPTH FEET (METRES)	DEPTH IN FEET (M) (RT) WELL STATUS
Mobil Sable	43° 56' 04.9"	Bawden	67-06-07	26.9 (8.2) KB	15,106 (4604.3) ✧
Island C-67	59° 55' 01.4"	Rig 18	68-01-02	12.8 (3.9) GL	P & A
Shell Onondaga	43° 43' 16.14"	Sedneth 1	69-09-01	85.0 (25.9)	13,085 (3988.3) ✧
E-84	60° 13' 17.41"		69-11-11	190.0 (57.9)	P & A
Shell Oneida	43° 14' 57.36"	Sedneth 1	69-11-16	85.0 (25.9)	13,516.7 (4119.9) ✧
O-25	61° 33' 36.49"		70-02-10	270.0 (82.3)	P & A
Shell Naskapi	43° 29' 46.78"	Sedneth 1	70-02-16	85.3 (26)	7235 (2205.2) ✧
N-30	62° 33' 59.54"		70-03-19	312 (95.1)	P & A
Shell Mohawk	42° 42' 10.52"	Sedco H	70-05-03	103.0 (31.4)	6975 (2126) ✧
B-93	64° 43' 53.50"		70-05-23	383.9 (117)	P & A
Shell Mic Mac	44° 36' 42.81"	Sedneth 1	70-03-25	85.3 (26)	12,750 (3886.2) ✧
J-77	50° 26' 10.86"		70-05-24	206 (62.8)	P & A
Shell Abenaki	44° 16' 34.49"	Sedco H	70-05-28	103.0 (31.4)	7147 (2178.4) ✧
L-57	59° 53' 39.64"		70-07-06	357 (108.8)	P & A
Shell Missisauga	44° 23' 20.39"	Sedneth 1	70-05-26	85 (25.9)	13,787 (4202.3) ✧
H-54	59° 22' 47.56"		70-07-20	335 (102.1)	P & A
Shell Onondaga	43° 44' 48.09"	Sedco H	70-07-09	103 (31.4)	10,874 (3314.4) ✧
O-95	60° 13' 52.60"		70-08-16	176.8 (53.9)	P & A
Shell Huron	44° 35' 47.10"	Sedneth 1	70-07-22	85 (25.9)	9903 (3018.4) ✧
P-96	58° 28' 50.63"		70-08-27	190 (57.9)	P & A
Shell Iroquois	44° 26' 31.37"	Sedco H	70-08-18	103 (31.4)	6845 (2086.4) ✧
J-17	59° 47' 12.28"		70-09-06	194.9 (59.4)	P & A
Shell Cree	43° 44' 20.70"	Sedco H	70-09-08	103 (31.4)	13,070 (3983.7) ✧
E-35	60° 35' 55.89"		70-11-03	174.9 (53.3)	P & A
Shell Mic Mac	44° 35' 27.71"	Sedneth 1	70-08-31	85 (25.9)	15,700 (4785.4) ✧
H-86	59° 27' 03.12"		70-12-02	178.1 (54.3)	P & A
Shell Wyandot	44° 52' 20.70"	Sedco H	70-11-07	103.0 (31.4)	10,005 (3049.5) ✧
E-53	59° 23' 54.05"		70-12-14	397 (121)	P & A

WELL NAME	LATITUDE LONGITUDE	DRILLING UNIT	SPUD DATE RIG RELEASED	RT ELEVATION WATER DEPTH FEET (METRES)	DEPTH IN FEET (M) (RT) WELL STATUS
Shell Argo F-38	45° 27' 23.22" 58° 50' 24.34"	Sedco H	70-12-17 71-02-19	103 (31.4) 234.9 (71.6)	11,110 (3386.3) P & A
Shell Fox I-22	45° 21' 33.60" 59° 33' 16.00"	Sedco H	71-02-20 71-03-03	103 (31.4) 274.9 (83.8)	2722 (829.7) P & A
Shell Abenaki J-56	44° 15' 44.95" 59° 53' 03.22"	Sedneth 1	70-12-04 71-03-13	85 (25.9) 350 (106.7)	14,991 (4569.3) P & A
Shell Erie D-26	44° 55' 03.52" 59° 34' 29.82"	Sedneth 1	71-03-16 71-04-11	85 (25.9) 321.9 (98.1)	7795 (2375.9) P & A
Mobil-Tetco Esperanto K-78	44° 47' 31.26" 59° 11' 19.24"	Sedco H	71-03-09 71-04-24	103 (31.4) 225.1 (68.6)	11,615 (3540.3) P & A
Shell Crow F-52	45° 21' 24.23" 59° 08' 22.73"	Sedneth 1	71-04-12 71-04-27	85 (25.9) 310 (94.5)	4943 (1506.6) P & A
Shell Sauk A-57	44° 16' 05.70" 58° 37' 44.41"	Sedneth 1	71-04-30 71-07-10	85 (25.9) 196.9 (60)	15,010 (4575) P & A
Mobil-Tetco Dauntless D-35	44° 44' 08.26" 57° 20' 46.62"	Sedco H	71-04-26 71-07-16	103 (31.4) 227 (69.2)	15,555 (4741.2) P & A
Shell Chippewa L-75	44° 34' 35.87" 58° 41' 50.54"	Sedneth 1	71-07-12 71-08-02	81 (24.7) 222.1 (67.7)	6,975 (2125.9) P & A
Shell Onondaga F-75	43° 44' 17.84" 60° 11' 36.25"	Sedco H	71-07-28 71-09-07	103 (31.4) 185 (56.4)	12,765 (3890.8) P & A
Shell Triumph P-50	43° 39' 51.62" 59° 51' 02.36"	Sedneth 1	71-08-04 71-10-10	85 (25.9) 295.9 (90.2)	15,077 (4595.4) P & A
Mobil-Tetco Sable Island E-48	43° 57' 20.35" 60° 07' 24.44"	Bawden Rig 14	71-05-28 71-10-15	21 (6.4) 0 (0)	11,820 (3602.7) P & A
Shell Eurydice P-36	45° 25' 47.30" 60° 04' 46.97"	Sedco H	71-09-15 71-10-24	98.1 (29.9) 540 (164.6)	9,728 (2965.1) P & A
Shell Chippewa G-67	44° 36' 20.50" 58° 39' 44.62"	Sedco H	71-10-28 71-12-18	98.1 (29.9) 230 (70.1)	12,040 (3669.8) P & A
Shell Mohican I-100	42° 59' 39.04" 68° 28' 51.32"	Sedco H	71-12-27 72-03-10	98.1 (29.9) 503 (153.3)	14,414 (4393.4) P & A
Shell Marmora C-34	43° 43' 13.79" 60° 05' 21.93"	Sedneth 1	72-01-15 72-03-31	85 (25.9) 189 (57.6)	13,248 (4037.9) P & A
Shell Primrose N-50	43° 59' 48.43" 59° 06' 51.63"	Sedco H	72-03-14 72-04-21	98.1 (29.9) 298 (90.8)	5,622 (1713.6) P & A
Mobil-Tetco Sable Island O-47	43° 56' 56.70" 60° 06' 38.08"	Bawden Rig 14	71-12-13 72-07-01	23 (7) KB 5.9 (1.8) GL	13,775 (4198.6) P & S
Shell-Mobil- Tetco Eagle D-21	43° 50' 06.73" 59° 34' 09.21"	Sedco H	72-04-22 72-07-02	98.1 (29.9) 168 (51.2)	15,290 (4660.4) P & A
Mobil-Tetco Sable Island I-H-58	43° 57' 27" 60° 07' 37"	Bawden Rig 9	72-06-03 72-08-27	35.1 (10.7) KB 5.9 (1.8) GL	9,971 (3039.2) P & S
Mobil-Tetco- Thebaud P-84	43° 53' 59.53" 60° 12' 19.34"	Sedco H	72-07-08 72-10-13	93.8 (28.6) 85 (25.9)	13,500 (4114.8) P & S
Mobil-Tetco Sable Island 2-H-58	43° 57' 27.14" 60° 07' 37.73"	Bawden Rig 9	72-10-06 72-12-31	34.8 (10.6) KB 5.9 (1.8) GL	9,050 (2758.4) P & S
Shell Primrose A-41	44° 00' 05.68" 59° 06' 18.26"	Sedco H	72-10-15 73-01-27	98.1 (29.9) 359.9 (109.7)	11,865 (3616.5) P & A

A P P E N D I C E S

WELL NAME	LATITUDE LONGITUDE	DRILLING UNIT	SPUD DATE RIG RELEASED	RT ELEVATION WATER DEPTH FEET (METRES)	DEPTH IN FEET (M) (RT) WELL STATUS	
Shell Primrose F-41	44° 00' 29.55" 59° 07' 06.52"	Sedco H	73-01-30 73-03-05	98.1 (29.9) 225.1 (68.6)	8,505 (2592.3) P & A	☼
Mobil-Tetco Sable Island 3-H-58	43° 57' 27.2" 60° 07' 37.8"	Bawden Rig 9	73-01-01 73-03-21	34.8 (10.6) KB 5.9 (1.8) GL	12,270 (3739.9) P & S	☼
Shell Marmora P-35	43° 44' 59.36" 60° 04' 47.58"	Sedco H	73-03-06 73-04-21	98.1 (29.9) 174.9 (53.3)	13,428 (4092.9) P & A	☼
Mobil-Tetco Bluenose G-47	44° 06' 20.79" 59° 21' 27.35"	Sedco J	73-01-25 73-04-25	98.1 (29.9) 267.1 (81.4)	15,050 (4587.2) P & A	☼
Shell Tuscarora D-61	44° 40' 10.35" 58° 55' 10.85"	Sedco H	73-04-23 73-06-02	98.1 (29.9) 258.9 (78.9)	12,925 (3939.5) P & A	☼
Mobil-Tetco Cohasset D-42	43° 51' 06.52" 60° 37' 13.89"	Sedco J	73-04-27 73-07-16	103 (31.4) 135 (41.1)	14,525 (4427.2) P & S	●
Mobil-Tetco Sable Island 4-H-58	43° 57' 27.2" 60° 07' 37.8"	Bawden Rig 9	73-03-22 73-08-11	34.8 (10.6) KB 5.9 (1.8) GL	14,827 (4519.3) P & S	☼
Shell Amoco Cap Rouge F-52	47° 11' 20.29" 61° 08' 15.32"	Sedco H	73-06-08 73-09-03	102 (31.1) 186 (56.7)	16,182 (4932.3) P & A	☼
Mobil-Tetco Sable Island 5-H-58	43° 57' 27.2" 60° 57' 37.8"	Bawden Rig 9	73-08-15 73-09-18	34.8 (10.6) KB 5.9 (1.8) GL	8,130 (2478) P & A	☼
Mobil-Tetco Sable Island 6-H-58	43° 57' 27.2" 60° 07' 37.8"	Bawden Rig 9	73-09-22 73-10-18	34.8 (10.6) KB 5.9 (1.8) GL	7,727 (2355.2) P & A	☼
Union et al Shell Ojibwa E-07	43° 46' 20.44" 61° 46' 14.42"	Sedco H	74-02-04 74-02-28	98.1 (29.9) 248 (75.6)	7,643 (2329.6) P & A	☼
Mobil-Tetco-Tezaco Citnalta I-59	44° 08' 42.58" 59° 37' 32.11"	Sedco J	74-02-04 74-04-29	98.1 (29.9) 310 (94.5)	15,010 (4575) P & S	☼
Shell Demascota G-32	43° 41' 27.2" 60° 49' 54.00"	Sedco H	74-03-01 74-05-20	98.1 (29.9) 178.1 (54.3)	15,329 (4672.3) P & A	☼
Union et al Sambro I-29	43° 38' 35.04" 62° 48' 17.04"	Sedco H	74-05-23 74-06-27	98.1 (29.9) 634.8 (193.5)	10,071 (3069.6) P & A	☼
Union et al Jason C-20	45° 29' 05.45" 58° 32' 28.27"	Sedco H	74-07-03 74-07-22	98.1 (29.9) 370.1 (112.8)	8,146 (2482.9) P & A	☼
Union et al Hercules G-15	45° 34' 20.65" 58° 47' 13.06"	Sedco H	74-07-23 74-08-01	98.1 (29.9) 379.9 (115.8)	3,547 (1081.1) P & A	☼
Texaco-Shell Intrepid L-80	43° 49' 35.78" 59° 56' 43.82"	Sedco J	74-05-18 74-08-15	103 (31.4) 143 (43.6)	13,655 (4162) P & A	☼
Murphy et al North Sydney P-05	46° 34' 46.24" 59° 45' 01.65"	Sedco H	74-08-10 74-09-07	98.1 (29.9) 206 (62.8)	5,449 (1660.9) P & A	☼
Union et al Montagnais I-94	42° 53' 40.71" 64° 13' 46.51"	Sedco H	74-09-12 74-09-29	98.1 (29.9) 370.1 (112.8)	5,400 (1645.9) P & A	☼
Mobil-Tetco-Gulf Adventure F-80	45° 19' 27.54" 57° 56' 22.80"	Sedco J	75-01-13 75-02-22	98.1 (29.9) 324.1 (98.9)	6,559 (1999.2) P & A	☼
Mobil-Tezaco Sachem D-76	44° 35' 09.22" 57° 41' 58.29"	Sedco J	75-05-17 75-07-30	98.1 (29.9) 191.9 (58.5)	16,006 (4878.6) P & A	☼
Shell Onondaga B-96	43° 45' 08.23" 60° 14' 09.63"	Sedco H	76-01-12 76-03-21	98.1 (29.9) 196.2 (60.4)	12,328 (3757.6) P & A	☼
Petro-Canada Shell Mic Mac D-89	44° 38' 08.86" 59° 28' 18.93"	Sedco H	76-03-26 76-05-04	98.1 (29.9) 279.9 (85.3)	10,552 (3216.4) P & A	☼

WELL NAME	LATITUDE LONGITUDE	DRILLING UNIT	SPUD DATE RIG RELEASED	RT ELEVATION WATER DEPTH FEET (METRES)	DEPTH IN FEET (M) (RT) WELL STATUS	
Petro-Canada Mobil Hesper I-52	44° 41' 40.33" 57° 52' 32.24"	Sedco H	76-05-08 76-06-05	98.1 (29.9) 138.1 (42.1)	9,200 (2804.2) P & A	✧
Shell et al North Sydney F-24	46° 33' 23.12" 59° 48' 45.47"	Sedco H	76-06-09 76-06-14	98.1 (29.9) 195.9 (59.7)	5,600 (1706.8) P & A	✧
Petro-Canada-Shell Penobscot L-30	44° 09' 43.55" 60° 04' 09.33"	Sedco H	76-07-18 76-09-23	98.1 (29.9) 451.1 (137.5)	14,000 (4267.2) P & A	✧
Petro-Canada-Shell Wenonah I-75	43° 34' 34.43" 60° 26' 13.72"	Sedco H	76-09-26 76-11-15	98.1 (29.9) 218.8 (66.7)	12,040 (3669.8) P & A	✧
Petro-Canada-Shell Moheica P-15	43° 04' 56.31" 62° 16' 44.32"	Sedco H	76-11-18 77-02-15	98.1 (29.9) 367.1 (111.9)	14,100 (4297.7) P & A	✧
Shell-Petro-Canada Penobscot B-41	44° 10' 02.44" 60° 06' 34.50"	Sedco H	77-02-18 77-03-30	98.1 (29.9) 386.8 (117.9)	11,300 (3444.2) P & A	✧
Mobil-Tetco-PEX Migrant N-20	43° 59' 56.24" 60° 17' 18.23"	Gulftide	77-07-29 78-01-23	85.6 (26.1) 44.9 (13.7)	15,317 (4668.7) P & A	✧
Mobil-Tetco-PEX Thebaud I-94	43° 53' 43.67" 60° 13' 38.13"	Gulftide	78-02-26 78-06-03	98.1 (29.9) 91.9 (28)	13,000 (3962.3) P & A	✧
Chevron-PEX Shell Acadia K-62	42° 51' 42.54" 61° 55' 00.21"	Ben Ocean Lancer	78-04-11 78-08-02	42 (12.8) 2841.9 (866.2)	17,343 (5286.1) P & A	✧
Mobil-Tetco-PEX Cohasset P-42	43° 51' 48.23" 60° 36' 16.62"	Gulftide	78-06-09 78-07-10	100.1 (30.5) 111.9 (34.1)	8,500 (2590.8) P & A	✧
Mobil-Tetco-PEX Cohasset L-97	43° 56' 37.19" 60° 29' 58.55"	Gulftide	78-07-13 78-11-13	100.1 (30.5) 70.9 (21.6)	15,984 (4871.9) P & A	✧
Mobil-Tezaco-PEX Venture D-23	44° 02' 15" 59° 34' 21"	Gulftide	78-11-28 79-06-16	104 (31.7) 65.9 (20.1)	16,224 (4945) P & S	✧
Mobil et al Venture B-13	44° 02' 11.61" 59° 32' 03.54"	Rowan Juneau	80-08-17 81-06-06	110.9 (33.8) 81.0 (24.7)	17,100 (5212) P & S	✧
Mobil et al Venture B-43	44° 01' 45.01" 59° 37' 21.03"	Rowan Juneau	81-07-06 82-04-25	110.9 (33.8) 66.9 (20.4)	19,265 (5872) P & S	✧
Petro-Canada et al Banquereau C-21	44° 01' 07.52" 58° 34' 00.24"	Bow Drill I	81-12-02 82-08-01	88.6 (27.0) 272.3 (83.0)	16,375 (4991) P & S	✧
Mobil et al Olympia A-12	44° 01' 03.27" 59° 46' 44.09"	Zapata Scotian	82-04-23 83-01-10	125 (38.1) 130.9 (39.9)	19,895 (6064) P & S	✧
Mobil et al South Venture O-59	43° 58' 52.83" 59° 38' 08.49"	Rowan Juneau	82-04-29 83-01-02	116.1 (35.4) 80.1 (24.4)	20,262 (6176) P & S	✧
Petro-Canada et al Banquereau I-13	44° 12' 33.16" 58° 31' 49.38"	Bow Drill I	82-08-02 82-12-27	88.6 (27.0) 319.2 (97.3)	17,021 (5188) P & A	✧
Petro-Canada et al West Esperanto B-78	44° 47' 03.40" 58° 26' 11.22"	SDS Vinland	82-08-22 83-05-05	76.4 (23.3) 298.9 (91.1)	18,711 (5703) P & A	✧
Shell et al Shubenacadie H-100	42° 49' 28.43" 61° 28' 42.81"	Sedco 709	82-11-05 83-02-12	79.1 (24.1) 4839.2 (1475)	13,780 (4200) P & A	✧
Mobil et al Bluenose 2G-47	44° 06' 22.30" 59° 21' 23.05"	John Shaw	82-12-30 83-09-05	80.1 (24.4) 279.9 (85.3)	19,019 (5797) P & A	✧
Mobil et al Venture B-52	44° 01' 12.86" 59° 38' 07.76"	Rowan Juneau	83-01-19 83-10-27	111.5 (34.0) 65 (19.5)	19,554 (5960) P & A	✧
Mobil et al Arcadia J-16	44° 05' 43.58" 59° 31' 58.19"	Zapata Scotian	83-01-27 83-07-19	125 (38.1) 182.1 (55.5)	19,701 (6005) P & S	✧

A P P E N D I C E S

WELL NAME	LATITUDE LONGITUDE	DRILLING UNIT	SPUD DATE RIG RELEASED	RT ELEVATION WATER DEPTH FEET (METRES)	DEPTH IN FEET (M) (RT) WELL STATUS	
Petro-Canada et al S.W. Banquereau F-34	44° 03' 15.63" 58° 50' 21.60"	Bow Drill 1	83-02-20 83-08-30	81.7 (24.9) 373 (113.7)	20,371 (6209) P & A	✧
Shell-Petro-Can et al Glenslg J-48	43° 37' 39.00" 60° 06' 25.44"	Sedco 709	83-02-22 83-11-07	78.7 (24.0) 274.6 (83.7)	16,890 (5148) P & A	✧
Shell-Petro-Can et al Uniacke G-72	44° 11' 29.17" 59° 41' 09.75"	SDS Vinland	83-05-09 84-04-04	77.1 (23.5) 501.6 (152.9)	18,816 (5735) P & A	✧
Mobil et al Venture H-22	44° 01' 24.10" 59° 33' 06.10"	Zapata Scotian	83-07-26 84-04-16	125 (38.1) 78.7 (24.0)	19,501 (5944) P & S	✧
Husky-Bow Valley et al Glooscap C-63	43° 12' 09.85" 62° 09' 56.73"	Bow Drill 2	83-08-07 84-01-03	75.1 (22.9) 324.8 (99.0)	14,902 (4542) P & A	✧
Petro-Canada et al St. Paul P-91	47° 10' 57.88" 60° 13' 36.83"	Bow Drill 1	83-09-02 82-12-31	81.7 (24.9) 570.5 (173.9)	9,465 (2885) P & A	✧
Home et al Louisbourg J-47	44° 26' 43.08" 58° 21' 26.02"	Glomar Labrador 1	83-11-25	125.3 (38.2) 207 (63.1)	Drilling	
Shell-Petro-Can et al Alma F-67	43° 36' 18.04" 60° 39' 56.72"	Sedco 709	83-12-02 84-07-05	78.7 (24) 223.1 (68)	16,581 (5054) P & S	✧
Husky-Bow Valley Chebucto K-90	43° 39' 44.74" 59° 42' 52.05"	Bow Drill 2	84-01-06	75.1 (22.9) 364.8 (111.2)	17,172 (5234) Testing	
Husky-Bow Valley et al South Griffin J-13	44° 22' 37.60" 58° 01' 55.70"	Rowan Gorilla 1	84-01-08	129.9 (39.6) 208 (63.4)	Drilling	
Petro-Canada et al Bonnet P-23	42° 22' 49.08" 65° 03' 01.30"	Bow Drill 1	84-01-14 84-04-04	82 (25.0) 438 (133.5)	14,226 (4336) P & A	✧
Husky-Bow Valley Evangeline H-98	43° 17' 25.08" 60° 58' 49.51"	Bow Drill 3	84-03-27	75.1 (22.9) 570.9 (174.0)	11,037 (3364) TS*	
Shell-Petro-Can et al South Desbarres O-76	44° 05' 56.07" 59° 55' 59.02"	SDS Vinland	84-04-17	69.9 (21.3) 232 (70.7)	Drilling	
Petro-Can et al Dover A-43	44° 22' 09.02" 60° 06' 09.28"	Bow Drill 1	84-04-18 84-07-11	82 (25.0) 380.6 (116.0)	14,846 (4525) P & A	✧
Mobil et al West Venture N-91	44° 00' 45.90" 59° 44' 17.50"	Zapata Scotian	84-04-19	128.9 (39.3) 125 (38.1)	Drilling	
Mobil et al West Venture C-62	44° 01' 02.78" 59° 40' 00.93"	Rowan Juneau	84-05-19	110.9 (33.8) 53.8 (16.4)	Drilling	
Shell-PCI et at Glenslg E-58	43° 37' 17.20" 60° 08' 56.10"	Sedco 709	84-07-07	78.7 (24.0) 259.2 (79.0)	Drilling	

3 DIRECTORY OF ONSHORE WELLS 1946-1984

WELL NAME	LATITUDE LONGITUDE	COMPANY (OPERATOR)	SPUD DATE COMPLETION DATE RIG RELEASE	DEPTH IN FEET (M) WELL STATUS ¹
Sonoco #1A	45° 47' 05" 64° 13' 39"	Sun Oil Co. Ltd.	1946-04 1947-09-01	11,504 (3506)
NSDM Record #1711	45° 35' 30" 62° 30' 12"	Pictou Petroleum Co.	1946-05-16 1946-07-16	645 (197)
NSDM Record #1172	45° 35' 35" 62° 30' 15"	Pictou Petroleum Co.	1946-05-16 1946-07-16	36.5 (11)
NSDM Record #1096	46° 07' 55" 60° 00' 18"	Sydney Petroleum Co.	1946-09-01 1946-10-24	253 (77)
NSDM Record #1097	46° 08' 12" 59° 59' 58"	Sydney Petroleum Co.	1946-09-01 1946-10-24	233 (71)
NSDM Record #1098	46° 07' 06" 60° 01' 55"	Sydney Petroleum Co.	1946-09-01 1946-10-24	81 (25)
NSDM Record #1235	45° 58' 22" 60° 57' 06"	Little Narrows Petroleum Co.	1946-11-26 1947-07-08	327 (100)
NSDM Record #1236 Little Narrows #1	45° 58' 20" 60° 57' 06"	Little Narrows Petroleum Co.	1946-11-26 1947-07-08	1,614 (492)
NSDM Record #1452 Little Narrows #2	45° 58' 31" 60° 57' 09"	Little Narrows Petroleum Co.	1947-10-27 1948-04-22	2,004 (611)
NSDM Record #1453	46° 05' 49" 61° 14' 53"	Little Narrows Petroleum Co.	1948-08-09 1948-09-30	694 (212)
NSDM Record #1505	45° 44' 17" 62° 01' 05"	Nova Scotia Department of Mines	1949-07-13 1949-09-19	712 (217)
NSDM Record #1836 Salthole #7	45° 39' 08" 61° 52' 55"	Department of Trade and Industry	1952-01-24 1952-06-19	1,432 (436)
Inverness #1	46° 03' 42" 61° 23' 48"	Imperial Oil Ltd.	1958-08-26 1958-09-10	510 (155)
Inverness #2	46° 02' 06" 61° 22' 35"	Imperial Oil Ltd.	1958-08-26 1958-09-10	260 (79)
Inverness #3	46° 06' 54" 61° 11' 43"	Imperial Oil Ltd.	1958-08-26 1958-09-10	480 (146)
Inverness #4	45° 55' 30" 61° 27' 24"	Imperial Oil Ltd.	1958-08-26 1958-09-10	470 (143)
Inverness #5	46° 05' 12" 60° 09' 43"	Imperial Oil Ltd.	1958-08-26 1958-09-10	100 (30)
Inverness #6	46° 04' 58" 61° 09' 39"	Imperial Oil Ltd.	1958-08-26 1958-09-10	170 (52)
Lura #1 NSDM Record #2671	45° 39' 42" 61° 50' 50"	Lura Corporation Ltd.	1958-10-01 1958-12-12	1,993 (607)
Mabou #1	46° 01' 25" 61° 24' 03"	Imperial Oil Ltd.	1959-10-24 1959-12-31	5,145 (1568)
Port Hood #1	46° 01' 55" 61° 28' 57"	Imperial Oil Ltd.	1960-01-16 1960-04-11	9,840 (2999)
Pacific Fox Harbour C-96-V	45° 50' 56" 63° 30' 47"	Pacific Petroleum Ltd.	1963-12-10 1964-05-03	9,853 (3003)
Murphy et al Birch Grove #1	46° 08' 43" 59° 56' 05"	Murphy Oil Co. Ltd.	1968-02-08 1968-03-24	4,408 (1344)
Anschutz-Wallace Station #1	45° 46' 15" 63° 30' 30"	Anschutz Corp.	1972-12-22 1973-08-29	14,883 (4536)

A P P E N D I C E S

WELL NAME	LATITUDE LONGITUDE	COMPANY (OPERATOR)	SPUD DATE COMPLETION DATE RIG RELEASE	DEPTH IN FEET (M) WELL STATUS ¹
Gulf et al Hastings #1	45° 50' 35" 64° 04' 53"	Gulf Oil Canada Ltd.	1975-06-11 1975-08-11	9,644 (2939)
Soquip Acc. et al Noel #1	45° 12' 45" 63° 42' 17"	Soquip Acc. et al	1975-07-19 1975-08-13	4,750 (1448)
Bras D'Or Anschutz #1	45° 39' 10" 61° 53' 01"	Brador Oil Company Ltd.	1976-07-27 1976-08-14	3,427 (1045)
Bras D'Or 3-78	45° 52' 30" 61° 00' 20"	Chevron Standard Ltd.	1978 1979	627 (191)
3A-78	45° 52' 30" 61° 00' 20"	Chevron Standard Ltd.	1978 1979	597 (182)
Chevron-Irving Bras D'Or #1	45° 52' 30" 61° 00' 20"	Chevron Standard Ltd.	1979-09-21 1979-09-30	709 (216)
Chevron-Irving Bras D'Or #2	45° 52' 45" 61° 00' 05"	Chevron Standard Ltd.	1979-10-03 1979-10-15	1,230 (375)
Chevron-Irving Malagawatch #M-1	45° 52' 05" 60° 55' 18"	Chevron Standard Ltd.	1979-10-31 1979-11-23	3,110 (948)
Chevron-Irving Malagawatch #M-2	45° 52' 06" 60° 55' 18"	Chevron Standard Ltd.	1979-12-10 1980-01-11	2,005 (611)
Chevron Malagawatch #M-5	45° 51' 37" 60° 56' 10"	Chevron Standard Ltd.	1980-06-04 1980-06-28	1,192 (363)
Chevron Malagawatch #M-5A	45° 51' 37" 60° 56' 10"	Chevron Standard Ltd.	1980-06-29 1980-09-03	3,908 (1191)
Chevron Malagawatch #M-4	45° 52' 19" 60° 55' 02"	Chevron Standard Ltd.	1980-08-14 1980-10-19	4,006 (1221)
Chevron Malagawatch #M-3	45° 52' 04" 60° 54' 57"	Chevron Standard Ltd.	1980-09-07 1980-10-25	3,838 (1170)
Chevron Malagawatch #M-8	45° 51' 59" 60° 55' 53"	Chevron Standard Ltd.	1980-10-23 1980-12-11	3,947 (1203)
Chevron Malagawatch #M-10	45° 52' 16" 60° 58' 17"	Chevron Standard Ltd.	1980-10-31 1980-12-04	3,218 (981)
Chevron Malagawatch #M-6	45° 52' 01" 60° 56' 58"	Chevron Standard Ltd.	1980-12-09 1981-02-13	3,508 (1069)
Chevron Malagawatch #M-7	45° 52' 04" 60° 56' 25"	Chevron Standard Ltd.	1981-01-07 1981-02-17	2,877 (877)
Chevron Malagawatch #M-9	45° 52' 03" 60° 55' 53"	Chevron Standard Ltd.	1981-02-26 1981-04-14	3,648 (1112)
Chevron McIvor Point R-1/R-1W	46° 02' 05" 60° 55' 13"	Chevron Standard Ltd.	1981-05-06 1981-07-18	3,890 (1186)
Chevron-Irving Scotsburn #2	43° 38' 22" 63° 00' 10"	Chevron Standard Ltd.	1981-08-11 1981-11-29	8,655 (2638)
NSDM Record #7644	43° 34' 47" 62° 39' 48"	Nova Scotia Department of Mines and Energy	1983-01-12 1983-04-18	3,337 (1017)
Port Malcolm	45° 34' 50" 61° 17' 44"	Corkan Engineering of Canada Ltd.	1983-09-13 1983-10-16	3,582 (1092)
Bear Island	45° 34' 22" 61° 17' 54"	Corkan Engineering of Canada Ltd.	1983-09-30 1984-01-11	1,359 (414)
Loch Lomond	45° 46' 12" 60° 35' 27"	Corkan Engineering of Canada Ltd.	1983-10-28 1984-03-01	810 (247)
North Glen	45° 50' 31" 60° 31' 00"	Corkan Engineering of Canada Ltd.	1983-10-27 1984-03-02	4,120 (1256)

1. All holes P & A